Mobilizing Canada's Energy Advantage:

Leveraging Energy Technology Innovation and Efficiency to Drive Competitiveness and Future Prosperity

Energy and Mines Ministers' Conference

Sudbury, Ontario
August 2014

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Executive Summary

At the Energy and Mines Ministers' Conference (EMMC) 2013 in Yellowknife, Ministers recognized that energy technology innovation is critical to Canada's economic strength and future prosperity. New ideas and technological advances will enhance Canada's competitiveness and help deliver improvements in energy efficiency. This is key to fostering sustained economic growth, employment in existing and new industries and meeting environmental goals. It is in this context that the federal–provincial–territorial Energy Technology Working Group was tasked to develop an information base of governments' efforts to advance energy technology innovation in Canada. The purpose of this report and the associated Compendium (Annex A) is to provide a synthesis of Canada's overall approach to fostering energy technology innovation and an analysis of potential opportunities for enhanced collaboration and alignment of priorities.

Canada has been successful in translating an enviable resource endowment into a key pillar of the national economy. The global energy landscape, however, is changing rapidly and dramatically. Markets for Canadian energy products and technologies are shifting and global competition is increasing as countries increase their expenditures on energy research, development and demonstration (RD&D) and pursue further market shares. In a changing global energy landscape, technology innovation presents opportunities for significant economic growth, while at the same time addressing environmental challenges. Canada continues to face barriers to energy technology innovation such as high capital costs with long-term pay-outs, complexity and uncertainty, as well as limited access to global markets and venture capital. As a result, a continued focus on energy innovation will be critical to maintaining Canada's energy resource advantage and to offer the potential for significant economic growth over the next five to ten years.

The Canadian energy landscape is also extremely diverse, with jurisdictions having distinct priorities and capabilities that reflect their particular mix of energy sources and use. More broadly, there are thousands of players in Canada's energy innovation system, each with limited resources to invest in RD&D. Collaboration plays a critical role in energy technology innovation. Partnerships across the private and public sector help to focus limited capacity and resources on areas where Canada has an opportunity to excel. There is a strong need for greater communication, sharing of best practices and exploration of opportunities between governments and other stakeholders, including the private sector and academia.

The report highlights a number of conclusions and recommended next steps for Ministers, including:

Conclusions

- Energy technology innovation is key to Canada's competitiveness in a changing global landscape and presents opportunities for significant economic growth, while at the same time addressing environmental goals.
- All jurisdictions have established policy priorities related to energy technology innovation, with responsible resource development, economic growth and environmental protection being common areas of focus.
- Provinces and territories have varying energy profiles and prioritize RD&D in areas that align with their resource endowments. At the same time, most jurisdictions are making innovation investments across a broad portfolio of technology areas.
- Canadian governments are employing a suite of tools to stimulate energy innovation, from tax incentives and regulations to a wide range of direct funding programs, which are supporting thousands of energy RD&D projects across Canada.
- The Government of Canada is a major driver of energy technology innovation and is investing in all areas, with a significant focus on energy efficiency, fossil fuels and renewable energy. Federal investments alone represented 29 percent of total Canadian spending on energy RD&D in 2009–10.

- Significant collaboration is occurring at the level of individual projects, but less so at the level of broader technology clusters or policy program development.

- Recent analysis and engagement, such as the study by McKinsey and Co. and the Energy Innovation Roundtables, have provided valuable intelligence on specific technology opportunities in Canada, as well as potential areas of federal–provincial–territorial collaboration.

Next steps

Canadian federal, provincial and territorial governments are focused on promoting world-class innovation, expanding the use of renewable energy resources, enhancing the commercialization and deployment of energy-efficient technologies, and pro-actively addressing environmental challenges. In order to maximize the economic benefits to Canada from these efforts, EMMC Ministers may wish to consider the following three key actions that would aim to develop a deeper sense of common federal, provincial and territorial energy innovation priorities and identify appropriate mechanisms for enhanced federal–provincial–territorial collaboration:

i. **Pursue greater alignment of federal, provincial and territorial priorities and innovative ways to collaborate on energy technology innovation, including:**

   - looking at ways to align the timing and focus of federal investments to support shared priorities with provinces and territories
   - establishing shared priorities around interjurisdictional clusters with common objectives and interests (e.g. technology clusters)
   - identifying areas of innovation that are or should be considered shared national priorities

ii. **Pursue senior federal–provincial–territorial official discussion on energy technology innovation, which would:**

   - build on the dialogue initiated through the 2014 EMMC process, the Energy Innovation Roundtables, and the Canadian Energy Innovation Summit
   - share plans and priorities and engage experts and stakeholders to inform collaboration
   - identify specific opportunities for alignment and collaboration that could be pursued by the Energy Technology Working Group

iii. **Through the Energy Technology Working Group, explore opportunities for further study of specific technology areas:**

   - determine technology areas of interest to jurisdictions
   - share key documents and information on select technologies
   - recommend specific areas for future study

1. Introduction and Purpose

At the Energy and Mines Ministers' Conference (EMMC) 2013 in Yellowknife, Ministers recognized that energy technology innovation is critical to Canada's economic strength and future prosperity. New ideas and technological advances will enhance Canada's competitiveness and help deliver improvements in energy efficiency. This is key to fostering sustained economic growth, employment in existing and new industries, and meeting environmental goals. It is in this context that the federal–provincial–territorial Energy Technology Working Group was tasked to develop an information base of governments' efforts to advance energy technology innovation in Canada. The purpose of this report and the associated Compendium (Annex A) is to provide a synthesis of Canada's overall approach to fostering energy technology innovation and analysis of potential opportunities for enhanced collaboration and alignment of priorities.

2. The Energy Innovation Imperative

Innovation is a major driver of global energy transformation. The capability of countries to innovate will determine their global energy competitiveness in the decades ahead, and competition is intensifying.

The global energy landscape is undergoing significant and rapid change. The last decade saw extraordinary growth in energy demand, which is forecast to grow by another 33 percent by 2035, as the global economy doubles. More than 90 percent of the projected growth in energy demand will be driven by fast-growing and densely populated economies in the Asia-Pacific region. While demand for all forms of energy will increase, fossil fuels are expected to still supply 75 percent of global energy demand in 2035, down from 82 percent in 2011.[1] Low-carbon sources (e.g. renewables and nuclear) will meet about 40 percent of the increase in energy demand, with renewables supplying one-third of total global electricity output by 2035. Global challenges such as energy security, environmental degradation and energy access to alleviate poverty are driving innovation in energy use across all sectors of the economy. Improvements in global energy intensity[2] are expected to continue, decreasing by one-third by 2035, with China seeing the biggest gains. Despite significant improvements in energy efficiency and the rise of renewables, the energy sector will continue to be the biggest emitter and the source of two-thirds of global greenhouse gas (GHG) emissions.[3]

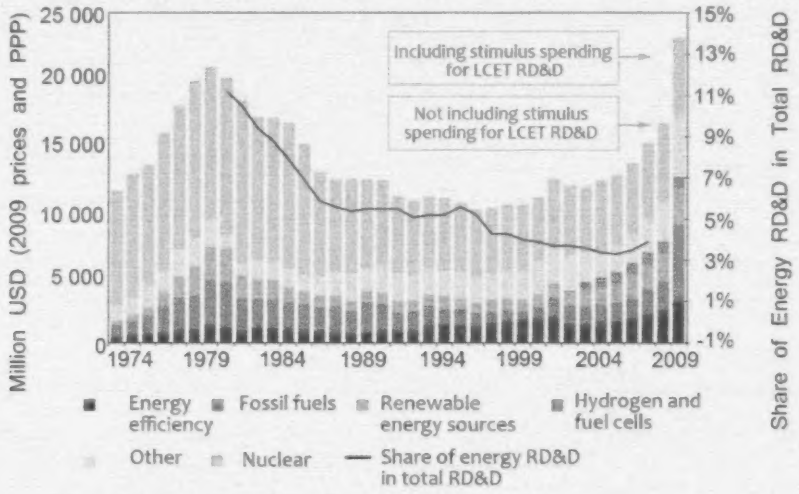
North American energy markets are being transformed by the unconventional oil and gas revolution and the increase in the price of oil. The deployment of advanced horizontal drilling and hydraulic fracturing (i.e. fracking) technology have also unlocked vast supplies of shale oil and gas. As a result, the United States (U.S.) is expected to be close to energy self-sufficient within the next decade; by 2020, it will become a net exporter of natural gas and the world's largest oil producer, reversing the steady decline in its oil production that began in the 1980s.[4] Already, shale gas is having a major impact in North America, with plans for liquefied natural gas (LNG) terminals changing from import to export facilities and a significant switch in U.S. electricity generation from traditional coal to cleaner-burning natural gas. These changing market dynamics are creating the need for Canada to seek new export markets, with a key opportunity emerging in the energy-hungry Asia-Pacific region.

Technology, including potential breakthroughs, will have a profound impact on the global energy system in the near term. Novel and advanced technologies have already unlocked major new oil and gas resources in recent years, including Canada's oil sands, and they will be the key to advancing renewable energy and energy efficiency and addressing environmental challenges, including GHG reduction. Despite the recent economic downturn and continued fiscal pressures, innovative effort is on the rise as a share of economic activity. Public expenditures on

[1] IEA, World Energy Outlook (2013).
[2] Energy intensity is defined as the amount of energy used to produce a unit of gross domestic product.
[3] IEA, World Energy Outlook (2013).
[4] IEA, World Energy Outlook (2013).

energy RD&D by IEA member countries have increased by 30 percent since the 1990s.[5] For example, U.S. public spending on energy RD&D has been reinvigorated over the past five years and is currently 50 percent higher than in the early 2000s.[6] Countries are renewing their public R&D programming and increasing their investments in energy technology innovation with an expectation of positive returns on investment. For instance, the European Union estimates an internal rate of return from RD&D investments of 15 percent from 2010 to 2030.[7] It is worth noting, however, that energy RD&D's share of total RD&D spending has been declining, from a high of 12 percent in 1981 to 4 percent in 2008 (Figure 1).

Figure 1. Government energy RD&D expenditure in IEA member countries, 1974–2009



Note: PPP - purchasing power parity.
LCET - low carbon energy technologies
Source: IEA databases, 2010 cycle. RD&D budgets for Czech Republic, Poland & Slovak Republic have not been included for lack of availability.

Economic stimulus spending helped drive energy innovation. Many of the economic recovery measures following the global economic downturn included investments in energy technology development and deployment. The IEA reports that at the end of 2009, major economies had allocated more than US$520 billion to clean energy technologies, including energy-efficiency retrofits for buildings, high-speed railways, smart grids and renewable energy. Canada's Economic Action Plan invested more than $3 billion over two years for technology and innovation, environmental science and post-secondary education and research.[8] This included $1 billion for the Green Infrastructure Fund, which supports projects that promote cleaner air, reduced GHG emissions and cleaner water (see text box). It also included $795 million for the Clean Energy Fund, which is providing support for RD&D projects to advance Canadian leadership in clean energy technologies. Federal, provincial and territorial governments worked together to identify priorities and to put resources together towards larger and more ambitious infrastructure projects.

Clean Energy Fund

The Clean Energy Fund was a component of Canada's Economic Action Plan announced in Budget 2009. In collaboration with provincial governments, the program has co-funded two large-scale demonstrations of carbon capture and storage (CCS) technology and 18 smaller-scale clean and renewable energy demonstration projects of a wide variety of technologies.

[5] IEA, Global Gaps in Clean Energy RD&D, (2010).
[6] IEA Energy RD&D Data set for 1974–2011, accessed in February 2014.
[7] IEA, Global Gaps in Clean Energy RD&D, pg 14 (2010).
[8] Available online at actionplan.gc.ca/en/page/stimulus-phase-canada-s-economic-action-plan-final-report-canadians.

3. Energy Innovation in Canada

Technology innovation is key to Canada's competitiveness in a changing global energy landscape and presents opportunities for significant economic growth, while at the same time addressing environmental challenges.

A strong foundation

Canada has been successful in translating an enviable resource endowment into a key pillar of the country's economy – fostering economic growth, attracting investment, creating employment and contributing to high living standards for Canadians. Hundreds of major Canadian resource projects are under construction or planned over the next 10 years, worth approximately $675 billion in investment. According to Statistics Canada, the value of Canada's natural resource assets stood at $785 billion in 2012 and has grown at an average rate of 3.5 percent annually over the last decade. Energy resources accounted for 56 percent of the value of all natural resource assets in 2012, followed by minerals (29 percent) and timber (14 percent). The energy sector directly contributes over 9 percent (or $155 billion) of Canada's GDP and 2 percent (or 300 000) of well-paying direct jobs, leading to an additional 200 000 indirect (e.g. construction) jobs. In 2012, energy accounted for nearly 25 percent of Canada's total public and private capital investment and 28 percent of total domestic merchandise exports.

Canada is fortunate to have some strong enabling conditions for energy technology innovation, and government is a key player. As a percentage of GDP, Canada ranks fifth in the IEA on public expenditures on energy RD&D. For the last three years, federal, provincial and territorial governments have together consistently spent more than $1 billion a year on energy RD&D. In 2009–10, public expenditures accounted for 43 percent of all Canadian investments in energy RD&D. Canada also ranks seventh in the OECD in R&D expenditures in the higher education sector, with 31 Canadian universities performing energy R&D and over 30 research chairs in energy. The federal and provincial governments not only fund energy innovation programs, but also undertake energy R&D in their own laboratories. Governments use science and technology (S&T) to meet their legal and regulatory responsibilities and to support national priorities. Their understanding of emerging technologies and the implications of their potential use in the marketplace provides the necessary evidence to develop and apply appropriate regulatory frameworks. This expertise also generates pre-competitive R&D that encourages private-sector investment by de-risking such potential commercialization opportunities. By making these discoveries accessible to private, academic and other government entities, public R&D provides expertise and resources resulting in viable products that give Canada a competitive edge in today's global market and improves the quality of life for all Canadians. Governments also maintain an attractive climate for RD&D investments by industry, including R&D tax credits and smart regulations, codes and standards. In 2010, 250 companies spent a combined $1.45 billion on energy RD&D. Enhancing private-sector investment in innovation has been identified as a key opportunity to enhance Canada's competitiveness.[9]

A continued focus on innovation will be critical to maintaining Canada's energy resource advantage and offers the potential for significant economic growth over the next five to ten years. Canada's prosperity will increasingly depend on addressing a range of challenges, including: accessing new export markets, accessing and developing new resources, maximizing efficient energy use to minimize the economic impacts of rising energy prices, managing environmental risks, sustaining and growing a strong and competitive investment environment, and ensuring an adequate supply of skilled labour. Energy technology solutions will play a critical role in addressing these challenges. Based on the experience of other countries (for example Norway in the oil and gas sector), successfully building the competitiveness in energy sectors and realizing the full potential of energy technologies can boost annual economic growth throughout the energy chain by up to 2 percentage points.[10] In Canada, this would translate into approximately $74 billion in incremental GDP and 500 000 new jobs by 2020.

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[9] World Economic Forum, *Global Competitiveness Report 2013* (2013).

[10] McKinsey and Co., *Opportunities for Canadian Energy Technologies in Global Markets* (2012).

Canada's Energy Technology Innovation Ecosystem

Canada has a strong foundation for sustaining an overall enabling environment for energy technology innovation. The country continues to benefit from highly efficient markets, well-functioning and transparent institutions, and excellent infrastructure. Canada is also successfully nurturing its human resources compared with other advanced economies, providing the workforce with the skills needed to succeed in a competitive economy.

Governments

Federal, provincial and territorial governments support energy technology innovation by promoting an environment that favours innovation throughout the energy economy. Canada is already using a range of policy instruments to create an enabling environment for energy technology innovation. The policy levers for strengthening energy innovation are multi-faceted and cut across federal and provincial jurisdictions, ranging from direct funding support for technologies in the RD&D phases and R&D in government laboratories; ensuring access to capital, global markets, and skilled labour; providing incentives through instruments such as standards, regulations, and tax incentives; and educating consumers.

Private sector

As a fundamental part of the energy innovation ecosystem, the private sector plays a critical role in bringing novel technologies to the marketplace to generate economic activity, create employment and bring forward real-world solutions to environmental challenges. Some private-sector companies carry out R&D, patent and license the new knowledge and technologies. The returns on investment in industrial R&D can be high for the firms undertaking it, the economy at large and, in particular, the region in which the activities take place.

Academia

Through their research activities, Canadian universities also play a critical role in linking Canada to the global pool of knowledge, technology and talent; developing young talent; and developing and advancing knowledge and its applications. Universities and colleges also provide education for future entrepreneurs and business leaders who are integral to enhancing Canada's competitive advantage.

Although each of the stakeholders has a role to play in advancing energy technology, collaboration is essential to accelerate the pace of discovery and commercialization. Collaboration and partnerships will play a critical in realizing the full benefits of the unique capabilities, interests and resources of all stakeholders.

Canada's science and technology ecosystem involves numerous players, including governments, businesses, universities and colleges, nongovernmental organizations (NGOs), communities and individuals. All participants in our science and technology ecosystem have a role to play in driving enhanced performance to elevate Canada to the ranks of the world's leading innovative economies, so that we might enjoy the economic and societal benefits associated with realizing our full science, technology and innovation (STI) potential. All players in Canada's STI ecosystem must embrace this responsibility – focusing our resources and efforts, looking to the lessons to be learned from global leaders, improving agility to take advantage of opportunities and working in concert to allow Canada to "run with the best".

Science, Technology and Innovation Council
State of the Nation 2012, Canada's Science, Technology and Innovation System: Aspiring to Global Leadership

Barriers to innovation

Energy technology innovation in Canada faces barriers. Innovation is and should be driven by the private sector; however, the energy sector faces challenges that can make it difficult for firms to realize the full benefits of technology investments. These "market barriers" can dissuade private-sector firms from investing in innovation and can lead to missed opportunities for the energy sector and for Canada. Some of the main barriers include:

Failure to capture positive externalities: Support for innovations that serve the national interest cannot be left to the private sector alone. This is because private markets do not generally exist for societal benefits such as improving public health and protecting the environment. Similarly, the private sector has tended to under-invest in RD&D that may be broadly beneficial to society – even where a market for the desired technology exists – because it is difficult for any individual firm to monetize all the benefits of these types of investments.

High capital costs and long-term pay-outs: Technological advances in the energy sector can involve high capital investments (i.e. $1 billion and higher) and can take decades to bring a return on investment. This applies to both the supply (e.g. power plants, pipelines and refineries) and demand side (e.g. buildings and automobiles). It increases the risk to individual firms and can slow the development and adoption of new technologies.[11]

Complexity and uncertainty: Investments in energy technology are inherently risky. The complexity and time involved in commercializing new technologies makes it difficult to predict the performance and markets for an innovative solution. Energy technology investments occur in an environment that can include significant price volatility, shifts in supply and demand, and uncertainty related to policy directions and regulations.

Access to markets and capital: Canada has a relatively small domestic market for emerging energy technologies, which means that innovative firms (e.g. clean technology small and medium-sized enterprises) must often rely on export markets to be competitive. Access to private funding and venture capital is also lower in Canada compared to other countries like the U.S., including the "smart and patient" capital that can be needed to move energy technologies from idea to market.[12]

Low perceived value of energy: Energy commodities are not valued for their inherent features or characteristics, but rather for the goods and services that they enable. This distinguishes the energy sector from other industries, such as information technology, where product differentiation is a key driver of innovation.[13]

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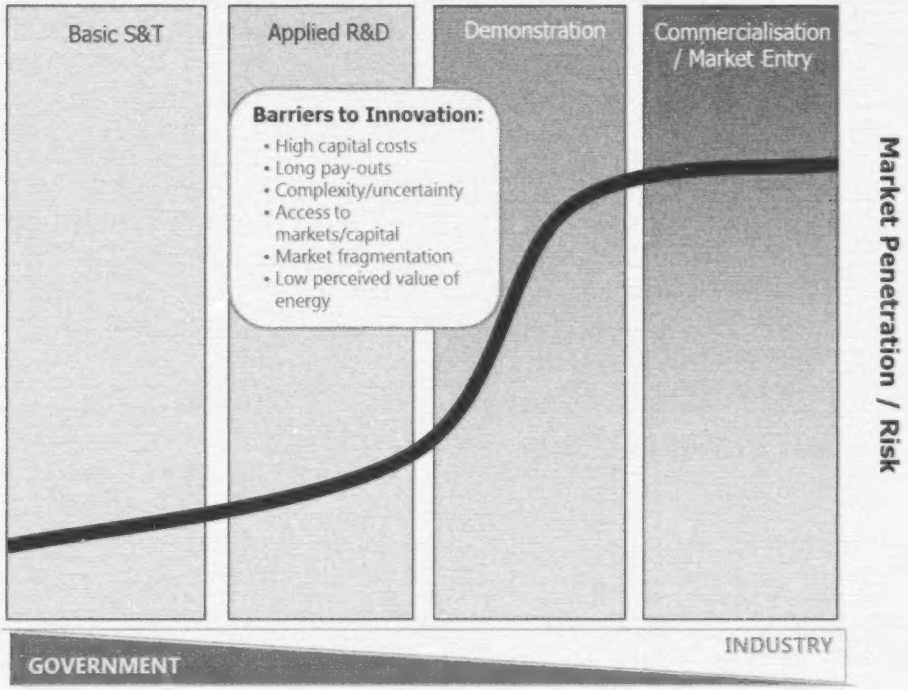
[11] American Energy Innovation Council, *Catalyzing American Ingenuity: The Role of Government in Energy Innovation* (2011), p. 11.
[12] McKinsey and Co., *Opportunities for Canadian Energy Technology Markets* (deck) (2012).
[13] American Energy Innovation Council, *Catalyzing American Ingenuity: The Role of Government in Energy Innovation* (2011), p. 11.

The innovation chain

Energy technology innovation is a cyclical process. It involves many actors who contribute to the development, demonstration, market readiness and deployment of new technologies. Typically, new technologies pass through a series of stages that drive an innovative idea from basic science to a marketable solution (Figure 2).

Figure 2: Innovation chain – From idea to marketable solution



Basic S&T is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied R&D can also involve original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. It also includes systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units.

Demonstration is the design, construction and operation of a prototype of a technology at or near commercial scale with the purpose of providing technical, economic and environmental information to industrialists, financiers, regulators and policy-makers.

Commercialization / Market Entry is the selection and use of a commercially available technology-based product or service in normal operations by businesses, individuals or government agencies with the aim of accelerating the diffusion and adoption of technologies or practices. At each phase of the energy technology innovation chain, public and private actors and institutions play a critical role in developing and financing innovative technologies, as well as facilitating their passage to the next technology stage.

Opportunities for Canadian Energy Technologies in Global Markets

In 2012, the Government of Canada commissioned a study by McKinsey and Co. to help identify global opportunities for Canadian energy technologies by 2020. The report, *Opportunities for Canadian Energy Technologies in Global Markets*, identified two key ways that Canadian governments can help sustain Canada's energy technology advantage. First, it emphasized the importance of creating an enabling environment for energy technology developers, including enhancing access to global markets, capital, and talent, and doing more to coordinate between institutions. Second, the study recommended targeted support to priority technologies, where governments are uniquely positioned to resolve barriers to Canadian competitiveness, including:

1) Sustaining Canadian advantage in unconventional oil and gas. Enabling the export of domestic oil and gas resources and secondarily by exporting the environmental technologies globally to mining and fossil fuel extraction markets (water treatment, emissions, land, remediation).

2) Cultivating Canadian leadership in next-generation transportation. Export of electric vehicle (EV) and plug-in hybrid electric vehicle (PHEV) automotive components to the global market and secondarily through domestic fuel-efficiency gains from the adoption of these technologies. Canada could capture domestic fuel efficiency gains and attract foreign investment by accelerating the adoption of electric/hybrid automobiles and natural gas heavy fleets.

3) Cultivating Canadian leadership in the energy-efficiency cluster. Increasing the global competitiveness of energy intensive Canadian industrial companies, secondarily by exporting energy-efficient buildings, industrial or water technologies and services as they are developed and, finally, by creating savings for Canadian industrial consumers on energy bills.

4) Investing selectively among distributed power generation technologies (unconventional hydro, biomass combined heat and power (CHP), waste-to-energy, solar off-grid) based on risks/rewards. Distributed power generation is an attractive emerging global market where Canada could commercialize technologies domestically with subsequent value creation through export.

5) Monitoring and investing carefully in long-term opportunities (post 2020). Biofuels/biorefinery, hydrogen fuel systems, and carbon capture and storage (CCS) all have questionable market size and timing, driven by either regulatory or technology uncertainty. Given its limited funds, the Canadian government would benefit from monitoring key indicators of market development before investing.

4. Analysis of Federal, Provincial and Territorial Approaches to Energy Innovation

Methodology and analysis

In order to understand the state of energy technology innovation in Canada, an assessment was conducted of the current tools and approaches being used by federal, provincial and territorial governments. This includes a review of policy directions, instruments, technology priorities, collaborative arrangements and expenditures. The analysis is based on two primary sources of information:

1. **Questionnaire submissions from federal, provincial and territorial governments:** In preparation for EMMC 2014, all provinces and territories and key federal organizations were asked to provide information on their energy RD&D activities via a questionnaire. Specific areas of focus were current policy directions, activities and tools being employed by federal, provincial and territorial governments, and the extent and nature of current collaboration between jurisdictions. The questionnaires also sought views on barriers, gaps and opportunities for energy technology innovation. The input from the questionnaire has also been compiled into a detailed compendium of current measures and initiatives.

2. **Annual IEA survey on public expenditures on energy RD&D:** Federal, provincial and territorial governments all contribute to this international survey, which is coordinated for Canada by Natural Resources Canada. The guidelines for the survey include precise definitions for each of the technology areas (e.g. renewables) referred to in this report and the figures within the report have been compiled using these provincial and territorial submissions. A complete guide to the IEA's survey methodology can be found at www.iea.org/stats/RDD%20Manual.pdf. While not all jurisdictions report in all years, Canada's survey response has been recognized by the IEA as world-leading in terms of data completeness and accuracy among IEA countries.

The analytical scan shows governments are engaged in a broad range of activities in supporting energy technology innovation in Canada. The results of the analysis are organized as follows:

A) Policy directions in energy technology innovation
B) Current activities and tools
C) Technology areas of focus for energy RD&D
D) Examples of collaborative arrangements

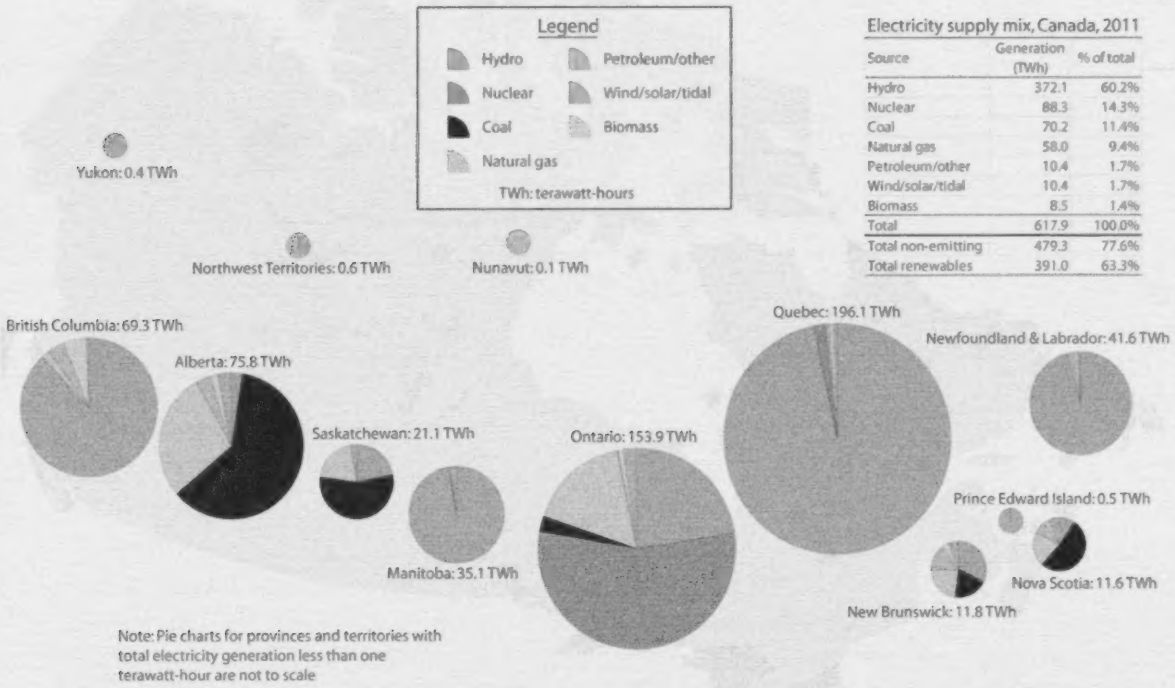
A) Policy directions in Canadian energy technology innovation

All jurisdictions have established policy priorities related to energy technology innovation with responsible resource development, economic growth and environmental protection being common areas of focus.

The Canadian energy landscape is diverse, and each jurisdiction has distinct priorities and capabilities that reflect its particular mix of energy sources and use. Canada is rich in fossil fuel resources, including those found in Western Canada, offshore Newfoundland and Labrador, southwest Nova Scotia and southern Ontario. In addition to resources already discovered, northern Canada is estimated to hold 40 percent of Canada's future discoveries of light crude oil and natural gas. Canada also has about 1 percent of the world's coal resources, 97 percent of which is found in the western provinces. On a regional basis, Alberta accounted for 63 percent of Canada's primary

energy production in 2010.[14] Other major energy producers were Ontario, British Columbia, Saskatchewan and Quebec. More than three-quarters of Canada's electricity comes from non-emitting sources. This is particularly concentrated in Quebec, Manitoba, British Columbia and Newfoundland and Labrador, which produce about one-third of electricity generated in Canada, 96 percent of which is hydro-generated. Ontario is the largest producer of nuclear energy and accounted for 26 percent of electricity generated in Canada in 2010, 54 percent of which came from nuclear sources.[15] As a result of uranium reserves in Saskatchewan, Canada is the world's second largest producer of uranium, a key strategic resource for Canada that is in demand in countries like China and India, which are building nuclear plants to meet their demand for electricity.

Canada's Electricity Supply Mix, 2011



Electricity supply mix, Canada, 2011

Source	Generation (TWh)	% of total
Hydro	372.1	60.2%
Nuclear	88.3	14.3%
Coal	70.2	11.4%
Natural gas	58.0	9.4%
Petroleum/other	10.4	1.7%
Wind/solar/tidal	10.4	1.7%
Biomass	8.5	1.4%
Total	617.9	100.0%
Total non-emitting	479.3	77.6%
Total renewables	391.0	63.3%

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Many provinces and territories have developed strategic policy frameworks and priorities to harness energy technology innovation. Canadian jurisdictions are focused on promoting world-class innovation, expanding the use of renewable energy resources, enhancing the commercialization and deployment of energy-efficient technologies, and pro-actively addressing environmental challenges. Most jurisdictions, including Alberta, Quebec, Manitoba, Ontario, British Columbia, Newfoundland and Labrador, Nova Scotia, Northwest Territories and Yukon have developed broad strategies related to energy, climate change and clean energy. Some provincial governments have put forward technology-specific (e.g. renewable, bioproducts, transportation and land-use) strategies and frameworks. For example, Newfoundland and Labrador has published an Energy Innovation Roadmap to identify key priorities

[14] nrcan.gc.ca/publications/statistics-facts/1239 accessed in March 2014.
[15] nrcan.gc.ca/publications/statistics-facts/1239 accessed in March 2014.
[16] Graphic produced internally by the Electricity Resources Branch of Natural Resources Canada.

and potential paths forward. As part of its Energy Blueprint, New Brunswick aims to develop a research and development strategy to support adoption of emerging clean-energy technologies. Saskatchewan is supporting innovation and the development of its natural resources, including energy-related activities, under the Saskatchewan Plan for Growth. Ontario's 2013 Long-term Energy Plan expects to offset almost all of the growth in electricity demand to 2032 by using conservation and energy demand programs as well as improved codes and standards. The Northwest Territories have developed the Solar Energy Strategy, which provides the framework for encouraging greater use of solar and less reliance on diesel fuel in the communities.

The Government of Canada continues to make science, technology and innovation a priority and is a major funder and performer of energy technology innovation, accounting for about 30 percent of all Canadian energy RD&D expenditures in 2009–10.[17] Canada's Science and Technology Strategy is focused on building Canada's talent, knowledge and entrepreneurial advantages to support jobs, growth and long-term prosperity for Canadians; the strategy is currently being updated based on consultations with Canadians. Through Economic Action Plans 2012 and 2013, the Government of Canada announced a new approach to supporting business innovation, with a focus on demand-driven policies, the use of procurement to provide incentives for innovative activity in firms, improved access to venture capital, augmented and more coordinated direct support to firms, and deeper partnerships and connections between the public and private sectors. In terms of energy technology innovation, the government is focused on fostering an innovative, globally competitive energy sector founded in responsible resource development creating economic benefits for Canadians. Natural Resources Canada is delivering on these objectives and has released its Science and Technology Strategy focused on building a sustainable resource advantage for Canadians through science and technology excellence.

B) Current activities and tools

Canadian governments are employing a full range of tools to stimulate energy innovation, from tax incentives and regulations to an extensive suite of direct funding programs, which are supporting thousands of energy RD&D projects across Canada.

Direct government investments in energy RD&D reduce financial and technology risks and attract additional investment from industry. A wide range of federal and provincial government programs exist across Canada, which fund R&D carried out in collaboration with industry, government laboratories and universities. A more complete list is provided in the Compendium (Annex A). Examples of current programs include:

- **The federal ecoENERGY Innovation Initiative (ecoEII)**, announced in 2011, will provide $268 million over five years for a comprehensive suite of clean energy RD&D activities to support energy technology innovation to produce and use energy more cleanly and efficiently.

- **The National Research Council of Canada (NRC)** has committed over $180 million over the next five to ten years for energy technology innovation. This is complementary to the investments under the Industrial Research Assistance Program (IRAP), which, over the past five years, contributed more than $84 million in support to small and medium-sized enterprises in Canada for innovation and commercialization related to energy technologies.

- **Sustainable Development Technology Canada (SDTC)** is a not-for-profit foundation (in operation since 2001) that finances and supports the development and demonstration of clean technologies which provide solutions to issues of climate change, clean air, water quality and soil, and which deliver economic, environmental and health benefits to Canadians.

- **British Columbia's Innovative Clean Energy (ICE) Fund:** The ICE Fund is a $25 million legislated funding tool designed to support energy and environmental priorities and advance British Columbia's clean energy sector.

[17] **Based on Statistics Canada and IEA Energy RD&D expenditure data for 2009–10.**

- **Alberta's Climate Change and Emissions Management Corporation (CCEMC):** Since 2007, Alberta's largest industrial emitters have been given mandatory requirements to achieve specific GHG reductions. As one compliance option, those that exceed allowable limits can pay into the Climate Change and Emissions Management Fund. Through an agreement with the Government of Alberta, this fund redirects money through the CCEMC to be re-invested into clean technology projects that will have an actual and sustainable impact on reducing GHG emissions. Since 2010, the CCEMC had committed funding to 53 innovative technology projects. In April 2014, the CCEMC announced 24 first-round winners for a $35 million **Grand Challenge** to develop technologies that can successfully enable new products and markets for CO_2.

- **Manitoba Hydro is making significant investment to implement a series of new hydro-electric development projects.**

- **Ontario's Smart Grid Fund:** Launched in 2011, the Fund invests in Ontario-based projects that support the growth and advancement of the province's electricity grid in order to help consumers' conservation efforts, manage energy costs and integrate new beneficial technologies like electric vehicles and storage.

- **Quebec's Technoclimat** is a green technologies demonstration program aimed at reducing GHG emissions under Priority 4 of the 2013–20 Climate Change Action Plan (CCAP). This CCAP measure encourages the emergence and deployment of technologies that show strong potential for reducing GHG emissions in Quebec.

- **Newfoundland and Labrador's Research and Development Corporation (RDC):** To date, the RDC, an arms-length provincial Crown corporation, has committed to invest $23.95 million in 67 energy R&D projects. These investments are in areas of competitive advantage with strong potential for economic return, notably in Arctic and harsh environment projects.

Regulations, codes and standards are promoting the development and adoption of new technologies, helping to open up new markets and saving Canadians money. For example, the Government of Canada has already developed **GHG regulations** for two of Canada's largest sources: transportation and electricity. Work continues on regulations for other major sources of GHG emissions, including the oil and gas sector. Canada has also finalized regulations setting progressively more stringent **fuel and GHG standards for passenger automobiles and light trucks** for model years 2011 to 2016 and for heavy-duty vehicles such as full-size pickups, semi-trucks, garbage trucks and buses. It is currently working with stakeholders to spur innovation and remove barriers to the deployment of **natural gas freight vehicles** through the development of refuelling codes and standards and on-board storage tanks so carriers have seamless operations. The National Model Building Codes play a major role in promoting the integration of energy-efficient technologies for new buildings, smart retrofit technologies for existing buildings, and micro-grid and storage technologies for residential applications by providing performance based standards. The integration of these technologies into the building design is expected to lead to a significant decrease of residential energy consumption in the future.

Provinces are also using codes, standards and regulations to stimulate energy innovation, including Nova Scotia's **Renewable Electricity Regulations**, under the province's *Electricity Act*, which provide a means for small- and large-scale tidal energy developers to qualify for feed-in tariff[18] for the power they produce. Alberta's Specified Gas Emitters Regulation is another example, which provides **GHG emissions intensity regulations** for major industrial facilities. The Saskatchewan government has recently amended existing regulations to clarify **the treatment of carbon capture and storage (CCS) activities**: the *Oil and Gas Conservation Act* was given royal assent by the Minister of Energy and Resources in May 2011, the *Pipelines Act* was amended in January 2011, and the *Crown Minerals Act* in late 2010. Manitoba has put in place **biofuels mandates, furnace efficiency requirements and a coal use tax**. In addition to the regulatory measures, progress is also being made on the developments of standards. Energy **performance requirements for 47 energy-using products** push the market to develop ever more efficient products

[18] A policy mechanism that offers cost-based compensation to renewable energy producers, providing price certainty and long-term contracts that help finance renewable energy investments.

and in 2020 will save Canadians the amount of energy required to power over three million homes. The Government of Canada, British Columbia and Ontario also established minimum efficiency standards for a range of products, with Ontario alone regulating 81 product categories. The development of such regulations and standards is underpinned by fact-based science and research, which is often supported by direct public spending.

Tax incentives are encouraging investment in energy technology innovation by reducing financial risks. Canada has one of the most generous tax incentive programs for business R&D in the industrialized world. The **Scientific Research and Experimental Development** (SR&ED) tax incentive program is the single largest federal program to stimulate business R&D in Canada. The SR&ED program provided businesses with more than $3.3 billion in tax assistance in 2013. In 2010–11, about 7 percent of SR&ED credits went to the "Utilities" and "Oil and Gas and Mining" categories combined.[19] **Income tax regulations**, including capital cost allowances, allow for accelerated depreciation for the cost of specified clean energy generation and energy conservation equipment. Certain expenses incurred during the development and start-up phases of clean energy generation and energy conservation projects can be fully deducted, carried forward indefinitely or transferred to investors using flow-through shares as **Canadian Renewable and Conservation Expenses**. In Saskatchewan, the **Petroleum Research Incentive** provides a 30 percent royalty/tax credit for eligible enhanced oil recovery pilot projects and demonstrations of new technology in the oil and gas sector. British Columbia and Quebec also offer tax credits to support R&D.

Access to capital attracts business investment in energy technology development. **Business Development Canada** promotes entrepreneurship by providing highly-tailored financing, venture capital and consulting services to entrepreneurs. Economic Action Plan 2013 provided an additional $325 million over eight years to **Sustainable Development Technology Canada**, a not-for-profit foundation that finances and supports the development and demonstration of clean technologies. The **Canadian Innovation Commercialization Program** (CICP), managed by Public Works and Government Services Canada, helps companies to bridge the pre-commercialization gap for their innovative goods and services by awarding contracts to entrepreneurs with pre-commercial innovations. The federal **Venture Capital Action Plan**, announced in January 2013, will invest $400 million in new capital over the next seven to ten years and is expected to attract nearly $1 billion in new private-sector investments to help innovative Canadian firms to grow and compete in global markets. Provinces are also supporting access to capital for clean technology innovation, including through Ontario's **Innovation Accelerator Fund**, British Columbia's **Renaissance Capital Fund** and the **Atlantic Venture Capital Fund** established by New Brunswick in partnership with Nova Scotia and Prince Edward Island.

Access to global markets for Canadian energy technologies is being facilitated through support for Canadian exporters and a modern intellectual property framework. **Export Development Canada** (EDC) helps Canadian companies respond to international business opportunities by providing insurance and financial services, bonding products and small business solutions to Canadian exporters and investors and their international buyers. In 2012, EDC formally launched its **clean technology commercialization strategy**, specifically to aid financing of earlier stage companies. It also collaborates with Sustainable Development Canada. In addition, this year the Government of Canada announced its proposal to modernize **Canada's intellectual property framework** by ratifying or acceding to recognized **international treaties**. This will make it possible for a company to obtain protection for trademarks in a number of countries through a single international application filed in one language, in one currency, with the International Bureau of the World Intellectual Property Organization, reducing paperwork and business costs.

Access to skilled labour is also essential in fostering energy technology innovation. Governments continue to invest in and collaborate with universities. Universities support innovative firms directly and indirectly through the strength of the research base, direct interaction and by producing highly-skilled graduates. Established over a decade ago, the **Canada Research Chairs** (CRC) program plays an important role in branding Canada's universities as hubs of world-class research and training grounds for the next generation of leading-edge scientists and highly-qualified personnel. There are currently more than 30 research chairs in energy. Canada is also home to six

[19] Expert Review Panel on Federal Support to R&D, *Innovation in Canada: A Call to Action* (2011), p.3–13.

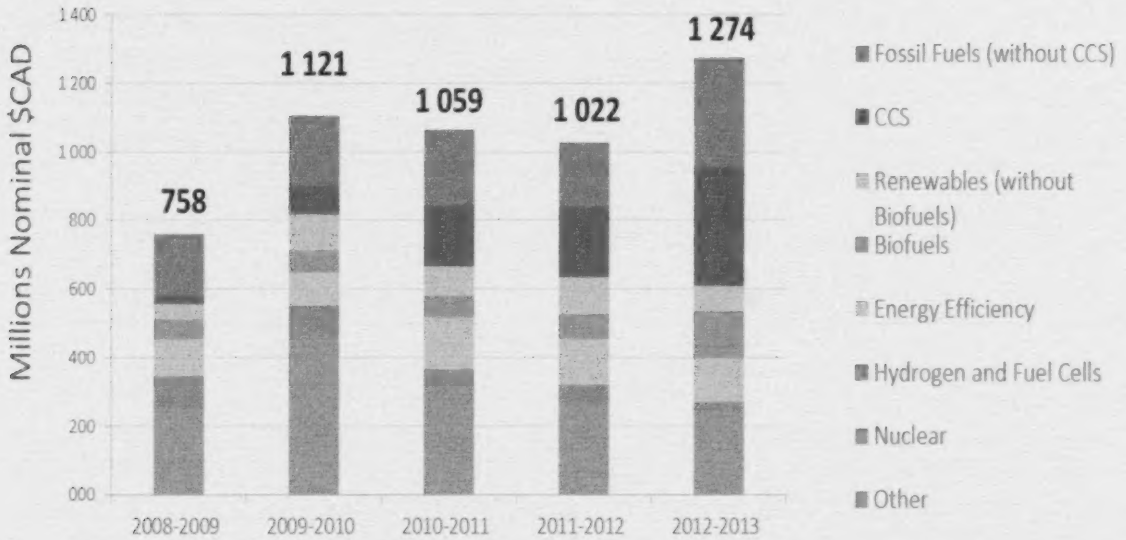
Network Centres of Excellence (NCE). Through programs such as the Centres of Excellence for Commercialization and Research (CECR) and the Business-Led Networks of Centres of Excellence (BL-NCE), the NCE is stimulating private-sector investment in research and innovation, with nearly half of partner contributions coming from industry. The **Canada First Research Excellence Fund**, announced in Economic Action Plan 2014, is expected to provide $1.5 billion to position Canada's post-secondary institutions to compete with the best in the world for talent and breakthrough discoveries.

Access to pilot R&D facilities promotes energy innovation in Canada. The Government of Canada provides access for innovators to pilot-scale technology demonstration facilities. For example, the **Canadian Centre for Housing Technology**, a collaboration between the National Research Council, Natural Resources Canada's CanmetENERGY laboratories and the Canada Mortgage and Housing Corporation, is a real-size technology demonstration facility for innovation related to residential housing. Other examples include **Alberta Innovates Technology Futures**, **Research and Development Corporation of Newfoundland and Labrador**, **l'Institut de recherche d'Hydro-Québec**, **Saskatchewan Research Council** and **Nunavut Research Institute**.

C) Technology areas of focus for energy RD&D

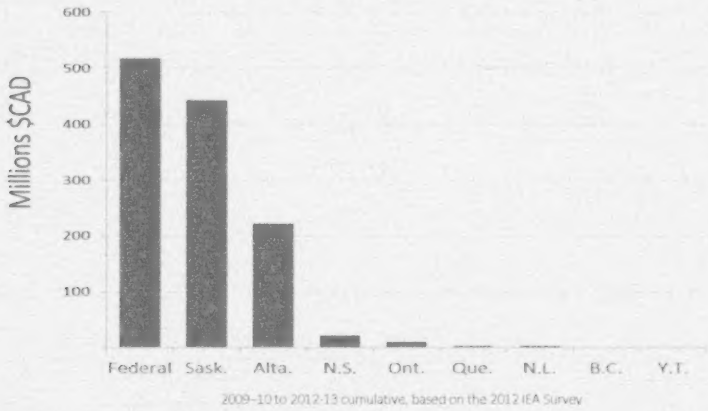
Provinces and territories prioritize RD&D in areas that align with their resource endowments. At the same time, many jurisdictions are investing in a diverse portfolio of energy technologies, including in the areas of fossil fuels, energy efficiency, renewable energy and biofuels, with fossil fuel supply capturing the largest share nationally (Figure 3).

Figure 3. Federal, provincial and territorial government investments in energy RD&D in Canada.



Fossil fuels and carbon capture and storage technologies dominate the mix, with over 50 percent of total investments in energy technologies in 2012–13. The fossil fuels area includes technologies for coal combustion, enhanced oil and gas production, refining, transport, and unconventional oil and gas production. Since 2009, nine jurisdictions have been engaged in oil and gas RD&D activities, with the Government of Canada, Alberta, Northwest Territories and Saskatchewan accounting for over a 90 percent of investments (Figure 4). The report by McKinsey and Co. highlighted opportunities for Canada related to unconventional oil and gas, including drilling and extraction technologies, water treatment, air quality and land remediation. McKinsey also emphasized the need for governments to foster collaboration across potentially competitive companies to facilitate the transfer of environmental technologies within industries and help reduce the cost base across industrial players. Six Canadian governments are also investing in coal combustion technologies, including the Government of Canada, Saskatchewan, Alberta, Northwest Territories and British Columbia.

Figure 4. Federal, provincial and territorial governments' energy RD&D expenditures for fossil fuels (without CCS) [20]



2009–10 to 2012-13 cumulative, based on the 2012 IEA Survey

Success Story: Shell Enhance Paraffinic Froth Treatment

Shell Enhance froth treatment technology was developed by Shell Canada in collaboration with Natural Resources Canada's CanmetENERGY laboratory in Devon, Alberta. NRCan scientists have been involved in research of froth treatment with a consortium of oil sands companies that at various times has included Syncrude, Suncor, Shell, Imperial Oil, CNRL, True North, Mobil, Total, Petro Canada, Synenco and Bitmen.

Compared to conventional froth treatment processes, Shell Enhance offers the following benefits:

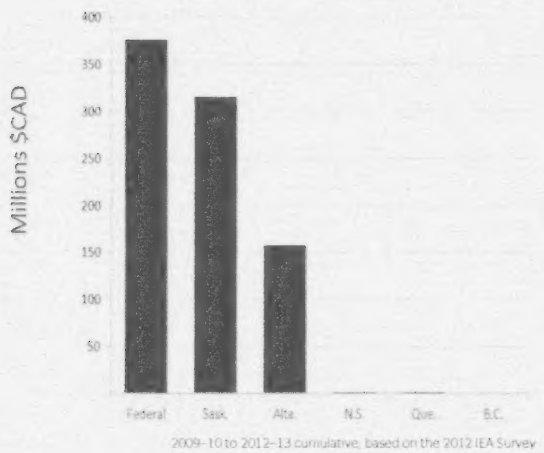
- improves energy efficiency by 10 percent
- requires a 35 percent smaller plant footprint with essential equipment 75 percent smaller
- uses 10 percent less water
- can be modularized, generating construction efficiencies and reducing costs

Shell Enhance was chosen by Shell for implementation at the Athabasca Oil Sands Project (AOSP). In 2009, AOSP Expansion 1 was one of the top 10 oil and gas construction projects in North America. In the same year, it was among the largest trade union projects in Canada with more than 5,000 skilled building trade members.

[20]Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report. In addition, Saskatchewan reports the SaskPower Boundary Dam CCS project as 50 percent coal and 50 percent CCS.

Carbon capture and storage (CCS) has received a significant share of Canadian energy RD&D investments in recent years through collaboration between the federal, Alberta and Saskatchewan governments. Today, Canada is recognized as a world leader in CCS with four large-scale projects under construction or in operation (see box at right). Canada is also the first major coal user to establish a ban on the construction of new traditional coal-fired electricity plants, which includes a regulatory incentive for the deployment of CCS technology to extend existing plants at end of life (i.e. 50 years). Saskatchewan's $389 million investment in the Saskpower Boundary Dam CCS project, which is equally split between the CCS and fossil fuels (i.e. coal) technology areas, was the single largest contribution to coal-related RD&D activities in Canada in 2012 (Figure 5). While annual Government of Canada support towards CCS has declined progressively since 2009, provincial support has increased for the same period. McKinsey and Co. identified CCS as a technology with potential longer-term opportunities for Canada. According to the IEA, globally, financial and policy commitments by governments to accelerate CCS demonstration efforts are required.[21]

Figure 5. Federal, provincial and territorial governments' energy RD&D expenditures for carbon capture and storage (CCS)[22]



Success Story: Canada a World Leader in CCS

Working collaboratively, the governments of Canada, Alberta and Saskatchewan have invested over $1.8 billion in funding for CCS to date, which is expected to leverage up to $4.5 billion in total public–private investment for CCS initiatives.

Canada has three large-scale CCS projects under construction and one large-scale CCS project in operation.

- SaskPower's Boundary Dam 3 project, expected to be commissioned in summer 2014, will be the world's first coal-fired power plant able to capture 90 percent of its CO_2 emissions, **which will then be used to boost the production of nearby oil fields**, as well as 100 percent of the sulfur dioxide emissions, and reducing the nitrogen oxide emissions by 50 percent.
- The Shell Quest Project in Alberta will capture and store more than one million tonnes of CO_2 per year from an oil sands upgrader starting in 2015.
- Another major CCS undertaking is the Alberta Carbon Trunk Line. It will capture and store 1.8 million tonnes of CO_2 per year from a fertilizer plant and a bitumen refinery starting in 2015, but is being constructed to handle up to 15 million tonnes of CO_2 a year.
- A fourth important project is the Weyburn-Midale Commercial CO_2-Enhanced Oil Recovery project, Canada's first CCS initiative. It currently injects up to 2.9 million tonnes of CO_2 per year, which is captured and transported to Saskatchewan from a chemical plant in North Dakota.

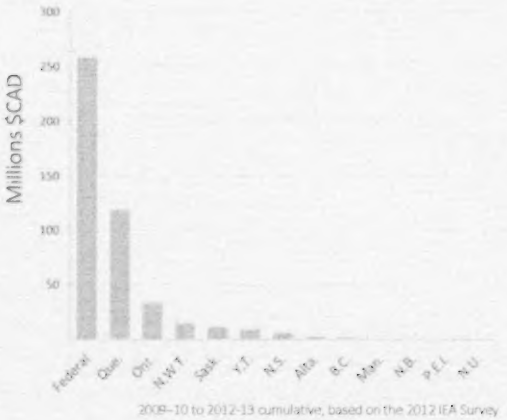
Alberta, in collaboration with other governments, industry and stakeholders recently released a report with recommendations to ensure the safety and environmental integrity of CCS. The analysis and recommendations in the resulting report place Alberta at the forefront globally of considering and addressing CCS regulatory issues, adding to Canada's leadership on CCS.

[21] IEA, *World Energy Outlook* (2013).

[22] Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report. In addition, Saskatchewan reports the SaskPower Boundary Dam CCS project as 50 percent coal and 50 percent CCS.

All provinces are encouraging the development and adoption of renewable energy technologies through policies, incentives and measures. These include renewable energy targets, legislated renewable portfolio standards and feed-in tariff programs to increase renewable energy supply for the electricity sector. For example, in Ontario, Nova Scotia and New Brunswick, utilities will purchase electricity produced from clean energy sources at more than the going rate (i.e. a feed-in tariff). Quebec's ÉcoPerformance and Biomass programs provide financial incentives of up to 75 percent of the installed cost of renewable energy systems reducing GHG emissions (e.g. solar, biomass and geothermal systems). Currently, 10 jurisdictions are investing in development and demonstration of solar energy technologies, with the Government of Canada accounting for 80 percent of total spending (Figure 6). Quebec's Programme ÉcoPerformance provides a financial incentive of up to 75 percent of the installed cost of solar thermal systems or 75 percent of solar installations for clean electricity generation. The Government of Canada has also made important investments in wind energy technologies through the ecoENERGY Innovation Initiative and the Clean Energy Fund. Over half of the direct energy RD&D support provided by Quebec is aimed at reducing the cost of geothermal energy technologies. With the recent completion of the Hermanville/Cleanspring Wind Development Project, PEI now generates more than 30 percent of its electricity requirements via wind energy. Based on their analysis, McKinsey and Co. highlighted distributed power generation (unconventional hydro, biomass combined heat and power (CHP), waste-to-energy and solar off-grid) as an attractive emerging global market where Canada could commercialize technologies domestically with subsequent value creation through export. The IEA estimates that half the increase in the world's electricity output to 2035 will come from renewables.[23]

Figure 6. Federal, provincial and territorial governments' energy RD&D expenditures for renewables (without biofuels)[24]



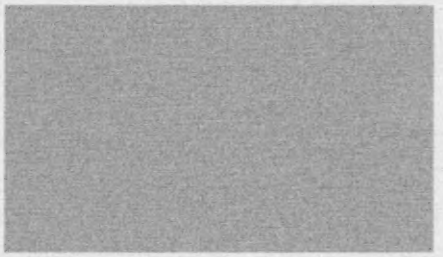
2009–10 to 2012–13 cumulative, based on the 2012 IEA Survey

Success Story: Morgan Solar Inc. Sun Simba HCPV Project – Ontario

The Innovation Demonstration Fund from the Government of Ontario invested $1.8 million in the development of a low-cost concentrated photovoltaic module called the Sun Simba HCPV.

The Sun Simba HCPV system and its successive product generations are expected to cost less than other solar power systems in the market and be one of the highest efficiency systems available on the market.

The impact of this technology is expected to result in substantial environmental benefits, increased adoption of solar energy for consumers, attractive returns to investors, skilled job creation in the local industrial community, and the manufacturing of cutting edge solar products for the global market.



[23] IEA, *World Energy Outlook* (2013).

[24] Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report.

Success story: Ramea Wind-Hydrogen-Diesel Pilot Project – Newfoundland and Labrador

Nalcor is currently operating a wind-hydrogen-diesel (WHD) project in Ramea, an island off the south coast of Newfoundland. It is focused on renewable energy storage and grid integration in an isolated diesel-powered community.

The first phase of the project involved the integration of existing diesel generators in Ramea with wind turbines and hydrogen equipment. The wind turbines provide energy directly to the Ramea grid during high-load periods and when the electrical load is low, the wind energy is used to produce hydrogen gas. Hydrogen gas is stored and converted back to electrical energy using a hydrogen powered generator when wind speeds are too low to operate the wind turbines. The renewable generation provided by the wind turbines and the hydrogen generator is used to offset diesel fuel consumption.

Nalcor's proprietary Energy Management System that automatically dispatches the various generating and storage equipment is undergoing preliminary patent work.

Phase one was jointly funded by the Government of Newfoundland and Labrador, the Atlantic Canada Opportunities Agency (ACOA), Natural Resources Canada and Nalcor. Phase two, which is now under way with funding from ACOA and Nalcor, will continue to test and optimize the system and will replace the hydrogen generator with hydrogen fuel cell technology.

View of Ramea Newfoundland

Success Story: Drake Landing Solar Community – Alberta

The Drake Landing Solar Community (DLSC) is a large-scale seasonal storage solar heating system project delivered by CanmetENERGY of Natural Resources Canada. Located in Okotoks, Alberta, the project successfully integrates energy-efficient housing, solar energy, district heating and energy storage technologies to fulfill greater than 90 percent of the space heating requirements for a 52-home community.

The objective of the system is to demonstrate the technical feasibility of achieving substantial energy savings using seasonal storage of solar energy for residential space heating. The system was the first of its kind in North America. The main challenge was bringing the knowledge and expertise in solar heating system design to an industry with no experience in the field. CanmetENERGY assembled the team of United Communities, Sterling Homes, ATCO Gas and the Town of Okotoks in 2005. The community came to fruition and solar energy began to flow into the energy storage system in June 2007.

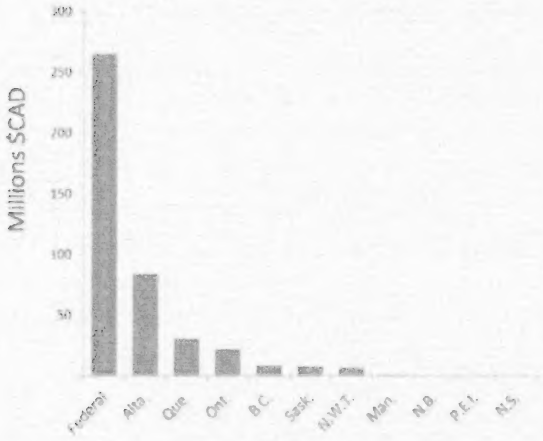
With the largest subdivision of R-2000 single family homes in Canada at the time and world record breaking system performance, the DLSC has reduced its carbon footprint by five tonnes of GHG per home per year.

The DLSC continues to garner recognition nationally and internationally, such as the International ENERGY GLOBE Award in 2011 and the International Energy Agency's Solar Heating and Cooling Award in 2013.

In its seventh year of operation the DLSC has not only met its goals for space heating requirements from solar energy but surpassed them and continues to break its own records for system performance. Discussions are under way with other Canadian municipalities as well as foreign governments to replicate the project within a larger community.

Renewables and biofuel energy technologies receive support from most Canadian jurisdictions. In 2012–13, these two technology areas received about $213 million in direct funding. This represents a 15 percent increase from the previous year and accounts for over 16 percent of total investments in all energy technology areas in 2012–13. Since 2009, biofuels have gained in importance. Alberta's investments in biofuels in Canada saw a sharp increase to about $80 million in 2012–13. As a result, investments in biofuels doubled between 2011–12 and 2012–13 in Canada. The Government of Canada continues to invest in biofuel technologies and provides over half of the total support. There are 10 jurisdictions advancing biofuel RD&D, but the focus varies across jurisdictions (Figure 7). Some jurisdictions are focused on the use and transformation of forestry biomass and others on the use and transformation of agricultural biomass. Prince Edward Island is also looking at opportunities to expand the use of biomass to heat public buildings, in the last year converting thirteen facilities to this renewable heat source. According to the analysis by McKinsey and Co., a long-term (10 years or longer) R&D investment starting today could enable Canada to take a leadership role in technology development in renewables and biofuels. The development of biofuel technologies is a priority for the IEA, specifically RD&D to improve cost and efficiency and to develop sustainable feedstocks.[25]

Figure 7. Federal, provincial and territorial governments' energy RD&D expenditures for biofuels[26]



2009–10 to 2012–13 cumulative, based on the 2012 IEA Survey

[25] IEA, *World Energy Outlook* (2013).

[26] Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report.

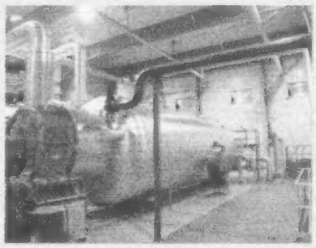
Success Story: Nechako Lumber Green Energy Project – British Columbia

A first for Canada's forest sector, Nechako Lumber Company Ltd., funded in collaboration with the Government of Canada, implemented an organic rankine cycle (ORC) system at its lumber processing facility to generate electricity using biomass-derived waste heat. Biomass power generation provides a stable source of green energy for the plant, replacing energy purchased from a utility. As a result of this project, an additional 2 MW of green power was installed in British Columbia.

Although Nechako Green Energy has not yet completed its first year of operation, the plant is on track to exceed the annual electricity production target. This renewable alternative is produced from waste heat that previously would have been vented to the atmosphere.

One of Nechako's biggest challenges was to understand how the innovative system fit with existing safety regulations. To overcome this, the company prepared a Safety Management Plan under the BC Safety Authority's Alternative Safety Approaches program. The plan was the first approved under this new initiative and as a result of their efforts, they received the BC Safety Authority Lieutenant Governor Safety Award for Excellence in Boiler, Pressure Vessel and Refrigeration Safety in 2013.

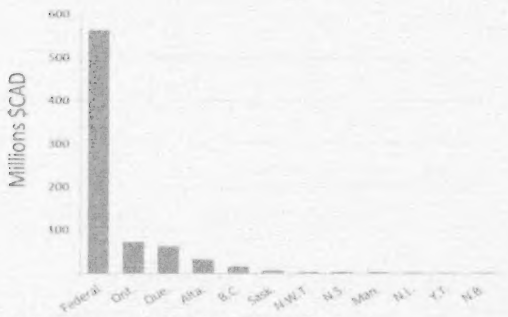
The project has provided Nechako Lumber with revenue diversification and stability. And now that the technology has been demonstrated, it has great potential for replication across the sector, creating similar benefits for other companies and communities.



The Organic Rankine Cycle turbine and condenser unit at the Nechako Lumber Company in Vanderhoof, B.C.

Investments in energy-efficiency technologies represented approximately 11 percent of the total Canadian government investments in energy RD&D in 2012–13. These efforts include the development of new and advanced energy-efficient technologies with the potential for commercialization and wide-scale deployment. Improving energy efficiency in the industry sector is a priority for many jurisdictions, including Ontario, Quebec, Alberta and the Northwest Territories. In all, seven jurisdictions provide direct support in this area (Figure 8). McKinsey and Co. has recommended investments in disruptive energy-efficient technologies for energy-intensive industries, water treatment technologies and waste-heat to power. According to the IEA, energy efficiency is set to supply more additional energy than oil through to 2035. Energy efficiency is the only fuel that simultaneously meets economic, energy security and environmental objectives.[27] In British Columbia, on the other hand, the majority of investments (over 75 percent) are focused on improving energy efficiency in the transportation sector. Next-generation transportation, such as electric motor raw materials, electric vehicles and natural gas vehicles, are areas highlighted by McKinsey and Co. for their export potential. Manitoba and Newfoundland and Labrador are also investing in energy efficiency in the transportation sector. Similarly, half of the federal government's investments in this area since 2009 have focused on the transportation sector, with the other half split equally between the residential, commercial and industrial sectors. Most recently, the ecoENERGY Innovation initiative is investing up to $23.5 million in R&D focused on energy efficiency in buildings and communities and in industry.

Figure 8. Federal, provincial and territorial governments' energy RD&D expenditures for energy efficiency[28]



2009–10 to 2012–13 cumulative, based on the 2012 IEA Survey

[27] IEA, *World Energy Outlook* (2013).

[28] Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report.

Success Story: Pulse Energy – British Columbia

Founded in 2006 with support from the Government of Canada and the Government of British Columbia, the company has gained recognition as a leader in the fast-growing market of building-performance improvement and optimization.

Pulse Energy has reduced costs and emissions in British Columbia's communities, including the three off-grid First Nations communities of Hartley Bay, Hesquiaht and Haida Gwaii through effective and efficient energy monitoring. Pulse Energy's proprietary software and know-how enabled users to become aware of their energy usage and to anticipate future energy demands. This is particular critical for remote communities, which rely on diesel generators and where the cost of power is very high.

Some notable highlights and accomplishments include:

- Technology Green 15™ Deloitte 2012 award recipient for leading the way to create major breakthroughs in the field of green technology.
- In 2014, Pulse Energy announced a multi-million dollar, three-year contract with BritishGas, the United Kingdom's largest energy supplier.
- Pulse Energy technology tracked energy use in all sports venues at the 2010 Olympic Games and the company was invited to assist with the London 2012 Olympic Games.
- Pulse Energy was a key NRCan partner on the Hartley Bay microgrid project.

Hartley Bay, B.C.

Success Story: Commercial Demonstration of a Charging Station Network Management System Project – Québec

In 2012, the Quebec Ministry of Energy and Natural Resources approved $2,672,653 in funding for AddÉnergie Technologies (AddÉnergie) under the Technoclimat Program in support of the commercial demonstration of a charging station network management system project.

Commercial demonstration of charging infrastructure

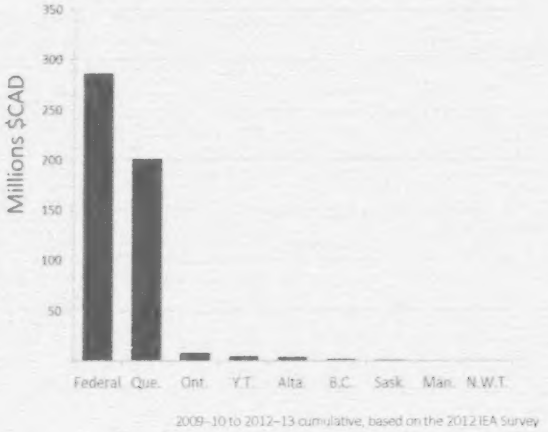
AddÉnergie designs, develops and commercializes intelligent charging station systems for electric and hybrid rechargeable vehicles. The charging stations are characterized by their resistance to harsh climates, remote control functionality through wireless communication and ease of configuration.

The objectives of the Technoclimat program include establishing and demonstrating a level-2 charging station network with 250 units controlled by a central management system, thus encouraging and facilitating the use of personal electric vehicles as a means of transportation in Quebec. AddÉnergie also plans to develop level-3 charging stations or "quick-charging" stations and to have them licensed and certified. A demonstration is planned to show the flexibility of centralized operation of an infrastructure with multi-level (level-2 and DC quick charge) smart charging stations. AddÉnergie's launch of their smart network management system will also lead the charging station network's operations by connecting all energy and service providers (Hydro-Québec, AddÉnergie and charging station facility owners) and registered clients (users who charge their electric vehicles).

Following a call for tenders, AddÉnergie was selected as the charging station supplier for Circuit électrique, the network operated by Hydro-Québec.

The development of smart grid technologies is a priority for several jurisdictions. The rapid increase in the share of distributed renewable electricity generation from wind power and solar photovoltaic (PV) is transforming power systems globally and this trend is likely to intensify in Canada, with significant variation in provinces and territories (Table 9). Since 2009, Quebec has led in terms of the level of RD&D investment in smart grids, followed by the Government of Canada and the Northwest Territories. This is also an important area for Ontario, which in 2011 launched its Smart Grid Fund to support growth and advancement of the province's electricity grid. Federal, provincial and territorial governments have also worked together to improve grid integration and distributed power generation issues resulting from rapid expansion of renewable energy deployment through the Federal-Provincial-Territorial Electricity Working Group.

Figure 9. Federal, provincial and territorial governments' energy RD&D expenditures for smart grids[29]



[29] Newfoundland and Labrador's R&D and innovation expenditures are reported in aggregate and as such may not show up as expenditures in particular areas of R&D and/or innovation identified in this report.

Successful Deployment of Innovation into the Marketplace

All jurisdictions have priorities related to energy innovation in order to support both economic growth and technological advance. Much activity is devoted to improving the efficiency of energy use in buildings and communities, in industrial processes and in fuels. When the results of such innovation reach the marketplace and gain widespread adoption, businesses find new customers and prosper. Consumers in all sectors save money and whole sectors operate with lower emissions.

Canada's federal, provincial and territorial governments not only support innovation efforts in research, development and demonstration, they also support the deployment of innovative products in the marketplace.

The following examples illustrate where energy-use innovation has made sectors more profitable and improved environmental performance.

Canada leads on home value: Leading-edge building standard becomes the norm as Canadian home builders push the limits

Today, Canadians are capable of designing and building some of the most energy-efficient homes in the world thanks, in large part, to government–industry collaboration on innovation to beat Canada's extreme climate with affordable, energy-smart home design. This innovation is now marketed around the world, generating export revenues for Canadian companies.

In 1977, the Saskatchewan Research Council broke new ground by building the first energy-efficient home. Based on this home, the Government of Canada partnered with the Canadian Home Builders Association and launched the R-2000 program in 1982.

For the first time, R-2000 took conceptual technologies and introduced them to builders and to the marketplace. This not only ensured the energy-saving technologies were used, but that they were implemented appropriately to realize the desired results. R-2000 incorporated new products such as house wrap to seal air leaks, heat recovery ventilators to keep air fresh and healthy, and high-performance windows to provide light, energy savings and comfort. R-2000 also introduced the concept of treating the house as a system which enabled builders to drastically improve the efficiency of a home without compromising its durability.

From a couple of dozen builders in 1982 to over 400 R-2000 builders today, over 14 000 R-2000 homes exist from coast to coast. The energy-efficiency lessons learned from R-2000 impact more than 80 percent of all new home construction in Canada. The cumulative energy savings in all new home construction attributable to R-2000 innovations and learnings over the last 30 years are equivalent to the yearly energy use of all Vancouver and Quebec City homes.

R-2000 is still driving innovation. The National Building Code released in 2012 is at the level of the 2005 R-2000 Standard. Therefore, as provinces and territories adopt the code, what was once leading-edge is becoming the norm, making all new homes more cost-effective to operate. The R-2000 standard was updated in 2012 to be 50 percent better than the new code, increasing comfort and realizing even more savings for homeowners.

An international adaptation of R-2000 has been exported to Japan, China, Korea and the United Kingdom, resulting in over $40 million of revenue to Canadian companies.

D) Examples of collaborative arrangements

There are thousands of players in Canada's energy innovation system, each with limited resources to invest in RD&D. Collaboration plays a critical role in energy technology innovation. Partnerships across the private and public sector help to focus limited capacity and resources on areas where Canada has an opportunity to excel. There is a strong need for greater communication, sharing of best practices and exploration of opportunities between governments and other stakeholders, including post-secondary institutions and the private sector.

Broad-based dialogue and collaboration

Energy innovation roundtables

A series of energy innovation roundtables were announced at the 2013 Energy and Mines Ministers' Conference to encourage collaboration and bring forth perspectives on how Canada can best support energy innovation. The roundtables garnered thoughtful contributions from more than 100 senior executives from industry, academia, utilities, governments, non-governmental organizations and the financial community. Five roundtable discussions took place across Canada, each focused on a specific energy technology area, namely: unconventional oil and gas, next generation transportation, energy-efficiency, distributed power generation and long-term research and development opportunities.

The thematic roundtables solicited views on barriers and solutions to accelerating energy innovation, and how best to align efforts and increase collaboration among key players. On June 23, 2014, Greg Rickford, Minister, Natural Resources Canada, and Jim Balsillie, Chair, Sustainable Development Technology Canada, co-chaired a national roundtable discussion on energy innovation in Waterloo, Ontario. This national event was the culmination of the five thematic roundtables and sought perspectives from leading senior-level stakeholders on solutions and opportunities for improving Canada's energy innovation potential and competitiveness. A number of common themes emerged from these discussions, including:

- Sustained leadership mobilized around shared objectives and common outcomes would help foster energy innovation in Canada. Governments have a strategic role to play as a convenor bringing together stakeholders across the innovation chain to resolve challenging and persistent issues.

- A market-driven RD&D portfolio, focussed on key Canadian energy strengths, would deliver benefits in the medium- to long-term to help enhance Canada's global competiveness.

- Public RD&D efforts could be better connected and aligned with industry needs, mindful of jurisdictions, to ensure a level of coherence across priorities and innovation system players. Strategic domestic and international partnerships and targeted funding can help to achieve this coherence, and an emphasis on demonstrations is important to showcase innovative technologies.

- An even stronger enabling environment could help spur innovation and better ensure that technologies are not stranded along the innovation chain. For instance, procurement programs help de-risk innovation while accessible energy information and data support good investment decisions.

- Gaps along the innovation chain exist, and several companies struggle to access capital. Building upon government-led initiatives will help support industry, particularly SMEs.

Canadian energy innovation summit

Held in March 2014, the Canadian Energy Innovation Summit brought together leading Canadian energy thinkers and practitioners to explore opportunities for environmentally responsible economic development and the vital role energy innovation will play. Several common themes emerged from the summit, including:

- Energy innovation will be critically important going forward, and governments have an essential role to ensure that Canada is successful.
- There is a need for greater collaboration between governments and other stakeholders, including post-secondary institutions and the private sector, in order to advance renewable energy and support Canada's growing clean technology sector.
- Export markets are going to be integral to Canadian cleantech innovation becoming a force in the global economy. Efficient technologies exist today, but their implementation requires the articulation of a clear and compelling business case.

Technology-specific collaboration

Alberta and Canada are collaborating on cleaner oil sands development. The two governments signed a memorandum of understanding (MOU) in 2012 to promote collaboration and alignment of oil sands and heavy oil research and innovation initiatives by fostering collaboration, by examining the shifting landscape in oil sands and heavy oil R&D, and by leveraging efforts with collaborative initiatives external to the MOU. New opportunities for collaboration are being identified in multiple ways.

The Atlantic Energy Gateway (AEG) initiative is enhancing regional cooperation towards the development of Atlantic Canada's clean and renewable energy resources. Announced in 2009, the AEG represents a collaborative approach among the Atlantic Canada Opportunities Agency, Natural Resources Canada, the Atlantic Provinces, regional power utilities and electricity system operators. The research, conducted under the AEG, identified significant potential benefits from regional collaboration, including development and operating-cost efficiencies, greater diversity in clean and renewable energy supplies, enhanced stability for ratepayers and lower GHG emissions for the Atlantic region.

The Government of Ontario recently announced an Advanced Energy Centre to bring together industry partners with utility and government representatives to advance next-generation energy technologies. Part of the MaRS Discovery District (a network of partners that help entrepreneurs launch and grow innovative companies), this new partnership initiative aims to transform local successes into international market opportunities. The Advanced Energy Centre was formally launched in early 2014, and founding corporate partners Siemens and Capgemini are already forging partnerships with the community of innovative small and medium-sized enterprises in energy technology to develop comprehensive "solutions-based" products that can compete and win in the global market.

Canada's Oil Sands Innovation Alliance (COSIA) is an industry-led alliance of 14 oil sands producers focused on accelerating the pace of improvement in environmental performance in Canada's oil sands through collaborative action and innovation with other industry, governments and academia. Participating companies capture, develop and share the most innovative approaches and best thinking, focusing on four priority areas: tailings, water, land and GHG emissions. To date, COSIA member companies have shared 560 distinct technologies and innovations that cost over $900 million to develop.

Canada and the Canadian Gas Association (CGA) are collaborating on energy efficiency, technology innovation and energy information. Activities include the promotion of natural gas in heavy- and medium-duty vehicles, which offers both economic and environmental benefits including fuels savings of up to 40 percent. Partners are working

with the water heater industry to pilot efficient water heaters that use on average 40 to 45 percent less natural gas than conventional heaters. NRCan and CGA are conducting joint R&D on highly-efficient small-scale combined heat and power units.

Canada is advancing energy science and technology through international fora. Canada is very active internationally. It participates in a number of international initiatives such as the Canada-U.S. Clean Energy Dialogue, Carbon Sequestration Leadership Forum (CSLF), Major Economies Forum and others. Canada is also a member of the IEA and has developed bilateral collaboration frameworks for science and technology with a number of countries. Examples include the Canada–China Science and Technology Agreement, the Natural Sciences and Engineering Research Council of Canada's MOU with Japan Science and Technology Agency (JST), the Canada–UK Joint Innovation Statement and the Canada–Israel Industrial Research and Development Foundation (CIIRDF), to name a few.

5. Conclusion

- Energy technology innovation is key to Canada's competitiveness in a changing global landscape and presents opportunities for significant economic growth, while at the same time addressing environmental goals.
- All jurisdictions have established policy priorities related to energy technology innovation, with responsible resource development, economic growth and environmental protection being common areas of focus.
- Provinces and territories have varying energy profiles and prioritize RD&D in areas that align with their resource endowments. At the same time, most jurisdictions are making innovation investments across a broad portfolio of technology areas.
- Canadian governments are employing a suite of tools to stimulate energy innovation, from tax incentives and regulations, to a wide range of direct funding programs, which are supporting thousands of energy RD&D projects across Canada.
- The Government of Canada is a major driver of energy technology innovation and is investing in all areas, with a significant focus on energy efficiency, fossil fuels and renewable energy. Federal investments alone represented 29 percent of total Canadian spending on energy RD&D in 2009–10.
- Significant collaboration is occurring at the level of individual projects, but less so at the level of broader technology clusters or policy program development.
- Recent analysis and engagement, such as the study by McKinsey and Co. and the Energy Innovation Roundtables, have provided valuable intelligence on specific technology opportunities for Canada, as well as potential areas for federal–provincial–territorial collaboration.

6. Next Steps

Canadian federal, provincial and territorial governments are focused on promoting world-class innovation for resources development and use, expanding the use of renewable energy resources, enhancing the commercialization and deployment of energy-efficient technologies, and pro-actively addressing environmental challenges. In order to maximize the economic benefits to Canada from these efforts, EMMC Ministers may wish to consider the following three key actions that would aim to develop a deeper sense of common federal, provincial and territorial energy innovation priorities and identify appropriate mechanisms for enhanced federal, provincial and territorial collaboration:

i. **Pursue greater alignment of federal, provincial and territorial priorities and innovative ways to collaborate on energy technology innovation, including:**

   - looking at ways to align the timing and focus of federal investments to support shared priorities with provinces and territories
   - establishing shared priorities around interjurisdictional clusters with common objectives and interests (e.g. technology clusters)
   - identifying areas of innovation that are or should be considered shared national priorities

ii. **Pursue senior federal–provincial–territorial official discussion on energy technology innovation, which would:**

   - build on the dialogue initiated through the 2014 EMMC process, the Energy Innovation Roundtables and the Canadian Energy Innovation Summit
   - share plans and priorities and engage experts and stakeholders to inform collaboration
   - identify specific opportunities for alignment and collaboration that could be pursued by the Energy Technology Working Group

iii. **Through the Energy Technology Working Group, explore opportunities for further study of specific technology areas:**

   - determine technology areas of interest to jurisdictions
   - share key documents and information on select technologies
   - recommend specific areas for future study

7. Collection of Success Stories

The following pages are a compilation of success stories in Canadian energy technology innovation that have been submitted by a variety of federal departments and provincial/territorial governments.

Energy Innovation and Efficiency Success Story

Drake Landing Solar Community – Natural Resources Canada

The Drake Landing Solar Community (DLSC) is a large-scale seasonal storage solar heating system project delivered by CanmetENERGY of Natural Resources Canada. Located in Okotoks, Alberta, the project successfully integrates energy-efficient housing, solar energy, district heating and energy storage technologies to fulfill greater than 90 percent of the space heating requirements for a 52-home community.

The objective of the system is to demonstrate the technical feasibility of achieving substantial energy savings using seasonal storage of solar energy for residential space heating. The system was the first of its kind in North America. The main challenge was bringing the knowledge and expertise in solar heating system design to an industry with no experience in the field. CanmetENERGY assembled the team of United Communities, Sterling Homes, ATCO Gas and the Town of Okotoks in 2005. The community came to fruition and solar energy began to flow into the energy storage system in June 2007.

With the largest subdivision of R-2000 single family homes in Canada at the time and world record breaking system performance, the DLSC has reduced its carbon footprint by 5 tonnes of greenhouse gases per home, per year.

The DLSC continues to garner recognition nationally and internationally, such as the International ENERGY GLOBE Award in 2011 and the International Energy Agency's Solar Heating and Cooling Award in 2013.

In its seventh year of operation, the DLSC has not only met its goals for space heating requirements from solar energy but surpassed them and continues to break its own records for system performance. Discussions are under way with other Canadian municipalities as well as foreign governments to replicate the project within a larger community.

Drake Landing Solar Community

Proponents:
United Communities, Sterling Homes, ATCO Gas and the Town of Okotoks

Funding:
NRCan: $2M; The Federation of Canadian Municipalities: $2.9M; Government of Alberta's Innovation Fund: $625,000; Alberta Environment: $500,000; Sustainable Development Technology Canada (SDTC): $1 million

Leverage:
Cash and in-kind: approx. 1:10

Partners:
The proponents and funders listed above.

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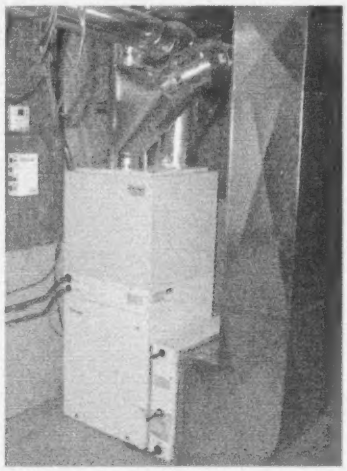
Energy Innovation and Efficiency Success Story

Local Energy Efficiency Partnerships – Natural Resources Canada

Natural Resources Canada's CanmetENERGY developed and delivers the Local Energy Efficiency Partnerships (LEEP) to enable home builders to find local solutions to building marketable, energy-efficient homes in a faster and cheaper way. The objective is for participating builders to construct homes that are 25 percent more energy efficient than code and include two to four of the innovations they have investigated through the LEEP initiative.

LEEP is a rapid, facilitated, turnkey process that can easily be replicated from market to market, introducing a group of builders to new technology options of their choice. The technologies are accompanied by CanmetENERGY's Technology Assessments, providing customized energy and cost analyses reflecting regional climate and business conditions. As builders progressively narrow their technologies of interest, the manufacturers and CanmetENERGY's experts address questions of integration with thousands of other housing components and systems, local supply channels and bulk costing for the builder group. Finally, new technologies and building practices are selected by builders for testing in their field evaluation homes, and experiences are fed back to CanmetENERGY to inform broader builder networks and to identify new research needs.

Seven major markets in Ontario and Manitoba have hosted LEEP sessions, involving over 60 new home builders (recruited by their Home Building Associations) who represent the majority of builds in their markets. LEEP is funded by electric and gas utilities as they foresee benefits to their demand-side management programs. Additional organizational support is provided by municipalities who seek to improve the link to their building code approval processes for new technologies and building practices.



This LEEP-builder selected zoned air handler technology improves temperature distribution while reducing energy consumption.

Proponents:

Home builders, utilities and housing technology manufacturers

Funding:

NRCan funding: $200,000; Utility and private-sector funding: $600,000 and in-kind support: $12 million

Leverage:

Cash only: 1: 3
Cash and in-kind: 1:63

Partners:

Ontario Power Authority; Enbridge; Union Gas; Manitoba Hydro; Hydro Ottawa; Hydro One; home building associations; municipal building departments.

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Energy Innovation and Efficiency Success Story

Shell Enhance Froth Treatment Technology – Natural Resources Canada

Shell Enhance froth treatment technology was developed by Shell Canada in collaboration with Natural Resources Canada's (NRCan's) CanmetENERGY laboratory in Devon, Alberta. NRCan scientists have been involved in research of froth treatment with a consortium of oil sands companies that at various times has included Syncrude, Suncor, Shell, Imperial Oil, CNRL, True North, Mobil, Total, Petro Canada, Synenco and Bitmen.

The technology uses high temperatures in the paraffinic froth treatment process to efficiently remove water, sand, fine clay particles and other impurities from oil sands froth. Compared to conventional froth treatment processes, Shell Enhance offers the following benefits:

- improves energy efficiency by 10 percent (equivalent to about 40,000 tonnes of greenhouse gases per year)
- requires a 35 percent smaller plant footprint with essential equipment 75 percent smaller
- uses 10 percent less water
- can be modularized, generating construction efficiencies and reducing costs

Shell Enhance was chosen by Shell for implementation at the Athabasca Oil Sands Project (AOSP). In 2009, AOSP Expansion 1 was one of the top 10 oil and gas construction projects in North America. In the same year, it was among the largest trade union projects in Canada with more than 5,000 skilled building trade members.

In 2003, the joint research team from NRCan and Shell was rewarded by the Alberta Science and Technology Leadership foundation for their innovative work in the Albian Sands commercialization of the paraffinic froth treatment process.

Froth treatment pilot facility, NRCan CanmetENERGY, Devon, Alberta

Proponent:
CanmetENERGY, Natural Resources Canada

Funding:
Natural Resources Canada: Program on Energy Research and Development – $120,000

Industry – $2,496,592

Leverage:
20:1

Partners:
Shell Canada

Key contact(s):
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Energy Innovation and Efficiency Success Story

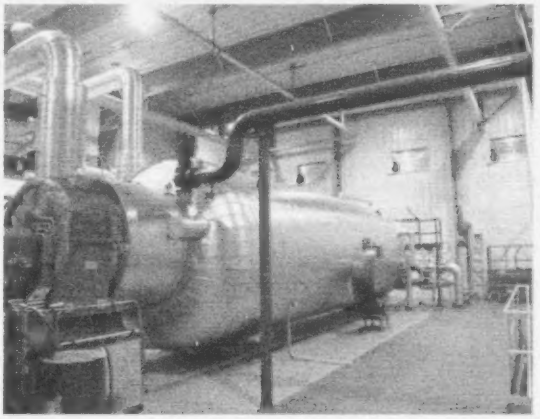
Nechako Lumber Green Energy Project – Natural Resources Canada

A first for Canada's forest sector, Nechako Lumber Company Ltd., in collaboration with the Government of Canada, implemented an Organic Rankine Cycle (ORC) system at its lumber processing facility to generate electricity using biomass-derived waste heat. Biomass power generation provides a stable source of green energy for the plant, replacing energy purchased from a utility. As a result of this project, an additional 2 MW of green power was installed in British Columbia.

Although Nechako Green Energy has not yet completed its first year of operation, the plant is on track to exceed the annual electricity production target. This renewable alternative is produced from waste heat that previously would have been vented to the atmosphere.

One of Nechako's biggest challenges was to understand how the innovative system fit with existing safety regulations. To overcome this, the company prepared a Safety Management Plan under the BC Safety Authority's Alternative Safety Approaches program. The plan was the first approved under this new initiative and as a result of their efforts, they received the BC Safety Authority Lieutenant Governor Safety Award for Excellence in Boiler, Pressure Vessel and Refrigeration Safety in 2013.

The project has provided Nechako Lumber with revenue diversification and stability. And now that the technology has been demonstrated, it has great potential for replication across the sector, creating similar benefits for other companies and communities.



The Organic Rankine Cycle turbine and condenser unit at the Nechako Lumber Company in Vanderhoof, BC.

Proponent:
Nechako Lumber Co. Ltd.

Funding:
BC Hydro: $4,700,000

IFIT: $2,095,278

Nechako: $184,066

Leverage:
30 percent

Partners:
BC Hydro

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Website: nrcan.gc.ca/forests/federal-programs/13139

Energy Innovation and Efficiency Success Story

Heat Recovery for Ice Rinks (CIMCO Refrigeration) – Natural Resources Canada

NRCan supported demonstration projects that allowed CIMCO to install its ECO Chill® system in three ice rinks. ECO Chill is designed to recycle 100 percent of the energy used to maintain the ice surface back into building heating systems. The system is based on the CoolSolution® approach developed by the CanmetENERGY Research Centre in Varennes, Quebec.

CIMCO estimates that by 2014, the ECO Chill installations had realized more than 350,000 tonnes of CO2 emission reductions which are equivalent to removing, for one year, 80,000 cars from the road, each driving 20,000 km in that year.

The demonstration installations represented an energy savings corresponding to 115 percent of the energy consumption of a typical Canadian ice rink for new buildings, 52 percent for retrofitted buildings

In the 10 years since 2004, CIMCO, has sold, installed and commissioned 172 ECO Chill® systems with a value of more than $200 million and employs more than 700 people. CIMCO was the main supplier of refrigeration systems to the 2010 Vancouver Olympic Games and is the official ice rink supplier to the National Hockey League.

One of the two ice rinks in the Dow Centennial Centre in Fort Saskatchewan, Alberta

Proponent:

CIMCO

Funding:

$885K NRCan Technology Early Action Measures (TEAM)

$300K NRCan Program for Energy Research and Development (PERD)

$120K NRCan Commercial Building Incentive Program (CBIP)

$85K NRCan Refrigeration Action Program for Buildings (RAPB)

Leverage:

$240K Hydro Québec

$10M Government of Québec (follow-on funding)

Key contact(s):

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Energy Innovation and Efficiency Success Story

Richmond Energy Garden and Composting Centre – Natural Resources Canada

The Richmond Energy Garden and Composting Centre, located in Richmond, British Columbia, uses an innovative high-solids anaerobic digestion (HSAD) technology to turn food scraps and yard waste into renewable energy and high-quality marketable compost.

The Richmond Energy Garden is now producing enough electricity to power 900 homes and up to 1 megawatt of that is being sold to BC Hydro.

The use of organic waste is expected to reduce greenhouse gas emissions by about 9000 tonnes of CO_2 equivalent each year. This is comparable to taking 2,300 mid-size cars off the road.

It is also helping Vancouver meet the Zero Waste Challenge goal of diverting 70 percent of the region's waste from landfills by 2015.

Currently, the City of Surrey, British Columbia, is developing a $65 million digester project modeled after the Richmond Energy Garden. The Surrey proposal successfully applied for $17 million of funding from the P3 Canada Fund in 2012.

The City of Edmonton is also considering the development of an HSAD facility and the P3 Canada Fund has seen increased interest in anaerobic digestion programs from other municipalities.

Harvest Power, the Richmond Energy Garden's parent company, believes similar HSAD facilities could process up to 15 percent of Canada's organic waste by 2020.

The Richmond Energy Garden and Composting Centre

Proponent:
Richmond Energy Garden and Compost Centre (Harvest Power)

Funding:
$5M NRCan

Leverage:
$1M Loan from BC Bioenergy Network

Key contact(s):
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Energy Innovation and Efficiency Success Story

La Cité Verte: Biomass Urban Central Heating Demonstration – Natural Resources Canada

NRCan is supporting the installation of a district energy system in a 15-building, eco-friendly housing and commercial development in Quebec City called La Cité Verte. The district energy system uses biomass in the form of wood pellets as fuel. Four wood pellet boilers heat two huge 22,000 litre tanks of water. The water is distributed through 2.2 kilometres of piping to meet the heating and domestic hot water needs of local residents and businesses.

The energy system's biomass boilers will reduce the greenhouse gas emissions normally associated with heating from oil or gas. Such boilers are CO_2 neutral as burning wood releases the same amount of energy as leaving that wood to rot in the forest. The wood pellets are a sustainable energy source made from waste wood, such as branches and brush from forestry operations.

This demonstration project is establishing baseline data to determine the operational performance of a biomass urban-based central heating system.

In combination with the district energy system and other features such as energy-efficient building materials and design, waste sorting, transportation management and the preservation of green spaces, La Cité Verte is expected to use 30 percent less energy than conventional developments.

La Cité Verte

Proponent:
SSQ Société Immobililère Inc.

Funding:
$4.7M NRCan

Leverage:
$5M Hydro Québec

$22.7M Government of Québec for civil engineering work that will be given back to Québec City

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Energy Innovation and Efficiency Success Story

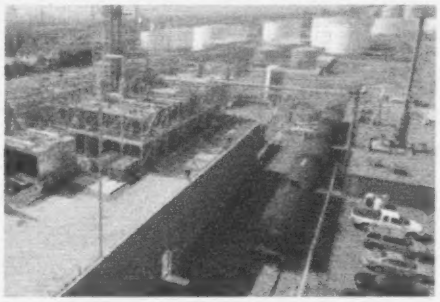
BIOX Canada – Sustainable Development Technologies Canada

BIOX Canada Ltd. has demonstrated a technology to convert agricultural seed oil, cooking oils/grease, animal tallows and fats into biodiesel at atmospheric pressure and near-ambient temperatures. It can also convert oils and fats to biodiesel faster than competing processes and avoids using valuable vegetable oils. BIOX believes these advantages will result in considerably lower production costs, making biodiesel competitive with petroleum diesel.

Results:

- Successfully completed construction and commissioning of a demonstration facility in 2007 after initial delays to correct design deficiencies.
- Produced the first million litres of biodiesel meeting ASTM D6751-6b standards in 2007 with clarity acceptable for diesel engine applications.
- Plant gradually achieving stable operations – produced over 18 million litres of biodiesel by the end of February 2008.
- During the first two years following the Sustainable Development Technology Canada (SDTC) project a total of 48.4 million litres of biodiesel were produced replacing petroleum diesel and resulting in greenhouse gas emissions reductions of 125 kt CO_2-e.
- Production of ethanol was 14.7 million litres in Q1 of 2011 as compared to 11.9 million litres in Q1 of 2010.

BIOX intends to build, own and operate biodiesel plants around the world with immediate plans to build facilities in Montréal, Philadelphia and Houston.



BIOX Canada

Proponent:

BIOX Canada Ltd.

Funding:

Total project value: $34,504,071
SDTC funding: $5,000,000

Leverage:

Leveraged Funding: $27,504,071

Partners:

Dynex Capital Ltd. Partnership Weatons Holdings Ltd.
CS Investment Capital Ltd.
Notae Investments Ltd.
Cotyledon Capital Inc.
Bi-Pro Marketing Ltd.
BIOX Corp.
FCC Ventures

Key contact(s):

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Energy Innovation and Efficiency Success Story

Westport Research Inc. – Sustainable Development Technology Canada

Westport Research Inc. has demonstrated a novel fuel injector technology which will prove the economic viability of operating heavy-duty (Class 8) trucks in a line-haul application using liquefied natural gas (LNG) as the primary fuel instead of pure diesel. By using LNG, truck operators will be able to meet the upcoming low-emissions standards while achieving significant cost reductions through the use of cleaner, less expensive natural gas.

Westport's high-pressure direct injection (HPDI) technology demonstrated:

- Significant reduction in NO_x, PM and carbon monoxide (CO) emissions compared to traditional diesel systems.
- Reduction in carbonyl compound and selected toxic hydrocarbon emissions over the diesel baseline.
- Potential for reduced greenhouse gas (GHG) emissions.

The Westport HD system substantially reduces air pollution, cutting nitrogen oxide emissions by 40 percent, particulate matter by 85 percent, carbon monoxide by 95 percent, carbonyl compounds by 85 percent and toxic hydrocarbons by 95 percent versus comparable diesel engine standards. With a combination of favourable LNG pricing and incentive funding, customers can achieve an aggressive payback period.

A study by TIAX LLC showed that trucks equipped with Westport Innovations' HD system could reduce their GHG emissions by more than 20 percent over 10 years / 400,000 miles. Looking specifically at the 8,400 trucks operating at California's San Pedro Bay ports, the study projected that the Westport HD system could eliminate 176,000 tonnes of CO_2-e emissions.

Natural Gas powered vehicle

Proponent:

Westport Research Inc.

Funding:

Total project value: $3,115,376
SDTC funding: $1,000,000

Leverage:

Leveraged funding: $2,115,376

Partners:

Enbridge Gas Distribution Inc.
Challanger Motor Freight Inc.
Natural Resources Canada
Transport Canada

Key contact(s):

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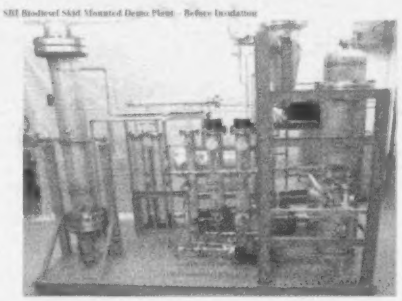
Energy Innovation and Efficiency Success Story

SBI BioEnergy Inc. – Sustainable Development Technology Canada

SBI has developed a patented catalytic process for producing drop-in renewable fuels from fats and oils. Potential fuel products include renewable diesel and renewable jet fuel. This process is unique in that it requires minimal energy input, no water, no hydrogen and the primary co-product is high-grade glycerine which can be sold in the health and pharmaceutical sector. They have piloted it to a 525,000 litre renewable fuel modular system and are seeking financing to build their first full-scale commercial facility.



SBI Biodiesel Skid Mounted Demo Plant – before insulation.

Proponent:

SBI BioEnergy Inc.

Funding:

Alberta Energy: $1,516,300
Alberta Environment EcoTrust: $4.9M
Alberta Innovates BioSolutions: $1.4M

Leverage:

Sustainable Development Technology Canada Tech Fund™: $1.8M
National Research Council Industrial Research Assistance Program: $579,228
Private funding: $5.2M

Partners:

SBI Fine Chemicals Inc.
Sustainable Development Technology Canada (SDTC)
Industrial Research Assistance Program
EcoTrust
Alberta Energy
Alberta Innovates BioSolutions
Quantiam Technologies Inc.

Key contact(s):

Jon Flemming
Vice-President – Public Affairs
E-mail: j.flemming@sdtc.ca

Energy Innovation and Efficiency Success Story

EQuilibrium™ – Canada Mortgage and Housing Corporation

EQuilibrium™ is a national Sustainable Housing Demonstration Initiative that brought the private and public sectors together to develop homes that combine highly energy-efficient construction practices with renewable energy technologies in order to reduce their environmental impact. Eleven projects were designed, built and demonstrated by home builder-led teams across Canada between 2007 and 2014.

The objectives of the EQuilibrium™ Housing initiative were to develop a clear vision and approach for low-environmental impact healthy housing; build the capacity of Canada's home building industry to design and build sustainable homes; educate consumers on the benefits of owning a sustainable home; achieve greater market acceptance of sustainable housing; and enhance Canada's domestic and international leadership and business opportunities in sustainable housing design, construction services and products.

Challenges included finding the appropriate balance between energy efficiency and conservation and renewable energy technologies to meet low-energy/net-zero energy goals. Occupant-related energy consumption choices and habits have a larger overall impact on energy consumption in highly energy-efficient homes. Establishing design specifications to provide targeted levels of performance can be challenging given the capabilities of existing energy modelling tools.

Through the construction and demonstration of 11 low-energy housing projects across Canada, the EQuilibrium™ Sustainable Housing Demonstration Initiative successfully demonstrated industry capacity to design and build low energy, sustainable housing. The practical examples provided through the EQuilibrium™ Housing initiative continue to support broader national and international efforts to commercialize net-zero energy housing by industry.

Green Dream Home, Kamloops, British Columbia

Proponent:

Canada Mortgage and Housing Corporation (CMHC)

Funding:

$1,756K Part IX NHA Funding

Leverage:

$430k Natural Resources Canada

$5k NRCan PERD

Key contact(s):

Duncan Hill
Manager
Sustainable Housing Policy and Research
CMHC

Thomas Green,
EQuilibrium™ Housing Team Leader,
CMHC

Energy Innovation and Efficiency Success Story

Pulse Energy – British Columbia

Pulse Energy has created an energy software system designed to improve the management of energy use in buildings and communities.

Founded in 2006, with support from federal and provincial governments, the company has gained recognition as a leader in the fast-growing market of building-performance improvement and optimization.

Pulse Energy has reduced costs and emissions in British Columbia's communities, including three off-grid First Nations communities of Hartley Bay, Hesquiaht and Haida Gwaii through effective and efficient energy monitoring. Pulse Energy proprietary software and know-how enabled users to become aware of their energy usage and to anticipate future energy demands. This is particularly critical for remote communities, which rely on diesel generators and where the cost of power is very high.

Some notable highlights and accomplishments include:

- Technology Green 15™ Deloitte 2012 award recipient for leading the way to create major breakthroughs in the field of green technology.
- 2014 Pulse Energy announced a multi-million dollar, three-year contract with British Gas, the United Kingdom's largest energy supplier.
- Pulse Energy technology tracked energy use in all sports venues at 2010 Olympic Games and the company was invited to assist with the London 2012 Olympic Games.
- Pulse Energy was a key Natural Resources Canada's partner on the Hartley Bay remote community smart microgrid project.

Hartley Bay

Proponent:

Pulse Energy

Funding:

British Columbia Ministry of Energy and Mines: Innovative Clean Energy Fund:– $2.42M

Sustainable Development Technology Canada – $2.5M

Partners:

British Columbia Ministry of Energy and Mines

Sustainable Development Technology Canada

CanmetENERGY, Natural Resources Canada

Aboriginal Affairs and Northern Development Canada

Key contact(s):

Bruce Cullen, Remote Communities Manager

Pulse Energy

Tel.: 1-877-331-0530

Website: www.PulseEnergy.com

Energy Innovation and Efficiency Success Story

Growing Power Hairy Hill L.P. – Alberta

Growing Power Hairy Hill L.P. is an integrated biorefinery that takes cattle manure from an adjacent feedlot, produces biogas for electricity and/or heat along with a fertilizer by-product, plus produces ethanol from grain using biogas-derived energy. The distillers grain by-product is then returned to the cattle feedlot as animal feed; waste heat from ethanol production also goes into warming the cattle feed and their water supply.

The partnership holds a patent on the entire process concept, as well as on the system to deal with manure mixed with dirt. Dirt mixed in with manure is not a problem for European biogas-from-manure producers (Europe is a biogas leader) because most feedlots have concrete floors. The manure separation process has potential applications in other jurisdictions where feedlots are dirt-based, especially less developed countries.

Growing Power Hairy Hill L.P. biorefinery

Proponent:
Growing Power Hairy Hill L.P.

Funding:
$20.2 million in bioenergy grants from Alberta Energy.

$31.1 million in Canada and Alberta program and agency loans

Leverage:
1:1

Partners:
Government of Alberta

Government of Canada

Agriculture Financial Services Corp.

24 Class A Unit Holders under the Limited Partnership

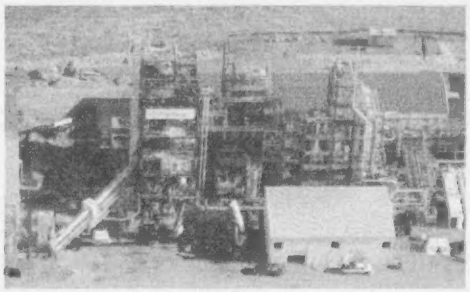
Key contact(s):
Eugene Natty Choimah, MBA,CGA, FCCA
General Manager
Growing Power Hairy Hill LP.
Tel.: 780-768-3809
Website: www.growingpower.com

Energy Innovation and Efficiency Success Story

Enerkem Biofuels – Alberta

Enerkem is one of the pioneering clean technology companies globally that produces biofuel and renewable chemicals from waste, including municipal solid waste (MSW), forest and agricultural residues. Enerkem is commissioning the world's first MSW-to-chemicals and biofuels facility in Edmonton, Alberta. It will be the company's first full-scale facility in North America and will produce biomethanol and ethanol fuel from the City of Edmonton's residential non-recyclable and non-compostable waste. At full capacity, it will produce 38 million litres of ethanol, enough to fuel 400,000 cars annually on a 5 percent ethanol fuel blend. Enerkem has previously piloted and demonstrated its proprietary transformative technology at its pilot and demonstration facilities in Quebec. The company is currently developing additional similar facilities in North America, including a plant in Varennes, Quebec.

Enerkem also provides the core technology for a world-class research center, which is the result of a partnership with the Government of Alberta and the City of Edmonton. The Advanced Energy Research Facility is adjacent to Enerkem's commercial waste-to-biofuels and chemicals facility in Edmonton. It focuses on the conversion of various waste into biochemicals and will expand Enerkem's proprietary technology platform to include additional useful products, such as polymers and higher alcohols while furthering the company's dedication to reducing greenhouse gas emissions.



Enerkem Alberta Biofuels facility under commissioning (official opening on June 4, 2014)

Proponent:

Enerkem

Funding:

Alberta Innovates – Energy and Environment Solutions and City of Edmonton: $20 million

Alberta Energy: $2.4 million

Climate Change and Emissions Management Corporation: $2.3 million

Investors:

Enerkem is majority-owned by institutional, clean-technology and industrial investors.

Partners:

Government of Quebec
Sustainable Development Technology Canada (SDTC)
City of Edmonton
Alberta Innovates – Energy and Environment Solutions
Alberta Energy

Key contact:

Marie-Hélène Labrie
E-mail: mlabrie@enerkem.com
Website: www.enerkem.com

Energy Innovation and Efficiency Success Story

Air Repressuring at Christina Lake – Alberta

Alberta has many high-quality bitumen deposits, some of which are in contact with several meters of gas zones. In some areas, these gas zones have been depleted and the pressure that remains is too far below what is required for efficient and economical recovery of bitumen using steam assisted gravity drainage (SAGD).

The Alberta Energy Regulator (AER, then ERCB) had shut in several gas zones as a preventative measure to ensure that the bitumen resource could be adequately protected and that no further at-risk zones could be depleted. This process was developed and tested to demonstrate that air re-pressuring efforts could be an effective solution where low-pressure SAGD was not an option in the presence of bottom water due to predictable water influx.

By re-pressuring the gas cap, the project objectives were to:

- establish that both the gas and bitumen resources can be recovered in a reasonable time frame, which would result in accelerated revenues for Alberta
- enable the proponent to determine the optimum operating pressure for the SAGD project and inject the appropriate amount of air into the depleted gas zone. In theory this would also improve the efficiency of the project resulting in fewer greenhouse gas emissions

To date the project has demonstrated that air could be used to safely and economically re-pressure the gas cap. The project documented an intersection of the gas cap and two live steam chambers which were thought to be detrimental to the project's operations. The operator was able to continue production without impairment to the production of bitumen and without negatively impacting facility operations. As a result of the air re-pressuring, the operations were able to remain stable proving that this technology was technically and economically viable for this operation.

Cenovus' Christina Lake SAGD oil sands operation in northern Alberta (September 2013)

Proponent:

Encana Corporation
Cenovus FCCL Ltd.

Funding:

$5,250,000 (Royalty Credit)

Leverage:

74.3 percent funded by proponent

Partners:

Encana Corporation
Cenovus FCCL Ltd.
Alberta Department of Energy

Key contact(s):

Martin Mader
Tel.: 780-644-3150
E-mail: martin.mader@gov.ab.ca

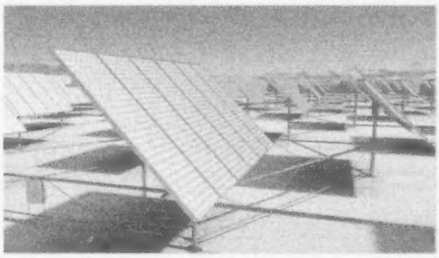
Energy Innovation and Efficiency Success Story

Morgan Solar Inc. Sun Simba HCPV Project – Ontario

The Innovation Demonstration Fund invested $1.8 million in the development of a low-cost high-concentration photovoltaic (HCPV) module called the Sun Simba HCPV.

The Sun Simba HCPV system and its successive product generations are expected to cost less than other solar power system in the market and be one of the highest efficiency systems available on the market.

The impact of this technology is expected to result in substantial environmental impacts, increased adoption of solar energy for consumers, attractive returns to investors, skilled job creation in the local industrial community, and manufacturing of cutting-edge solar products for the global market.



Sun Simba HCPV Project – Morgan Solar Inc.

Proponent:

Morgan Solar Inc.

Funding:

National Research Council of Canada – Industrial Research Assistance Program (IRAP); Ontario Centres of Excellence – First Job Fund; Ontario Ministry of Research and Innovation – Innovation Demonstration Fund

Leverage:

$1.8M in funding

Partners:

Ontario Ministry of Research and Innovation, National Research Council of Canada – Industrial Research Assistance Program (IRAP), University of Ottawa, Export Development Canada, Iberdrola Group, Enbridge Inc., The Frost Gamma Group

Key contact:

John Paul Morgan, President and Chief Technology Officer

Energy Innovation and Efficiency Success Story

AddÉNERGIE Technologies – Québec

In 2012, the Quebec Ministry of Energy and Natural Resources approved $2,672,653 in funding for AddÉnergie Technologies (AddÉnergie) under the Technoclimat Program in support of the commercial demonstration of a charging station network management system project.

AddÉnergie designs, develops and commercializes intelligent charging station systems for electric and hybrid rechargeable vehicles. The charging stations are characterized by their resistance to harsh climates, remote-control functionality through wireless communication and ease of configuration.

The objectives of the Technoclimat program include establishing and demonstrating a level-2 charging station network with 250 units controlled by a central management system, thus encouraging and facilitating the use of personal electric vehicles as a means of transportation in Quebec. AddÉnergie also plans to develop level-3 charging stations or "quick-charging" stations, and to have them licensed and certified. A demonstration is planned to show the flexibility of centralized operation of an infrastructure with multi-level (level-2 and DC quick charge) smart charging stations. AddÉnergie's launch of their smart network management system will also lead the charging station network's operations by connecting all energy and service providers (Hydro-Québec, AddÉnergie and charging station facility owners) and registered clients (users who charge their electric vehicles).

Following a call for tenders, AddÉnergie was selected as the charging station supplier for Circuit électrique, the network operated by Hydro-Québec.

Commercial Demonstration of Charging Infrastructures

Proponent:
AddÉNERGIE Technologies

Funding:
Total project value: $9.9 million

Quebec Ministry of Energy and Natural Resources (Technoclimat Program): $2.7 million

Partner:
Gentec

Key contact:
Tel.: 1-877-505-2674

Website:
www.addenergietechnologies.com

Energy Innovation and Efficiency Success Story

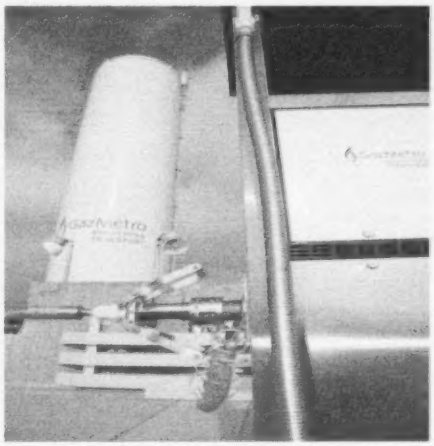
Gaz Métro Transport Solutions – Québec

The goal of the "Blue Road" demonstration project is to secure the first merchandise transportation corridor by liquid natural gas (LNG) in Canada on the Autoroute-20/Highway-401 route between Quebec City and Toronto. Each week, heavy-duty vehicles make approximately 48 000 trips along this road. The specific objective of this project is to replace diesel fuel with LNG, a much cleaner fuel.

This project is largely supported by the Government of Quebec, through tax measures that support the acquisition of LNG-powered heavy-duty vehicles and, in 2011, with financial assistance in the amount of $1,783,555 under the Ministry of Energy and Natural Resources' Technoclimat Program. This financial assistance was granted to help establish the infrastructure needed to adapt and finalize the environmental technology designed to reduce greenhouse gas emissions generated by road transportation of merchandise between Quebec City and Toronto. The project therefore contributed to the installation of the first two LNG filling stations in Quebec, located in Boucherville and Lévis.

Transport Robert established a partnership with Gaz Métro Transport Solutions for the portion of the project granted financial assistance under the Technoclimat Program. Fuel is the most expensive component in the trucking industry, and natural gas is more economical than diesel. By using natural gas to fuel a portion of its fleet, Transport Robert will reduce not only its environmental footprint, but its operating costs as well.

In April 2014, four LNG filling stations were operating: two stations at Transport Robert's facilities in Boucherville and Mississauga and two public stations on Gaz Métro Transport Solutions property in Lévis and Cornwall. Gaz Métro Transport Solutions plans to install three new stations in the near future.



The "Blue Road" Demonstration Project (LNG usage in the heavy transport industry)

Proponent:
Gaz Métro Transport Solutions

Funding:
Total project value: $5.4 million
Quebec Ministry of Energy and Natural Resources (Technoclimat Program): $1.8 million

Partner:
Transport Robert

Key contact:
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Gaz Métro Transport Solutions
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E-mail: EDesmarais@gazmetrost.com

Energy Innovation and Efficiency Success Story

Innoventé – Québec

In 2009, Innoventé received financial assistance through the Quebec Ministry of Energy and Natural Resources' Technoclimat Program for the demonstration of SHOC®, a technology for manufacturing biofuels from organic waste or BEFOR (BioEnergy From Organic Residues) through a carbon-neutral drying process that does not use fossil fuels. This bio-drying technology partially dehydrates, sanitizes and deodorizes organic materials under favourable energy-efficient conditions, with no environmental impact.

The project was carried out at three different testing sites (the F. Ménard farm in Saint-Dominique, Innoventé's facilities in Saint-Patrice-de-Beaurivage and the Chapais Energy cogeneration plant in Chapais). Testing was done under actual operating conditions to demonstrate the biodryer's operation, establish operating parameters and demonstrate the technical and environmental aspects of the complete SHOC® process for BEFOR production.

Financial assistance from the Technoclimat Program contributed to a regional model that will provide durable solutions for organic waste management by producing a clean and renewable energy source.

Following the project's acceptance under the Technoclimat Program and project start-up, Innoventé won three Hydro-Québec calls for tenders for electricity production by cogeneration in Saint-Patrice-de-Beaurivage (4.6 MW beginning in 2013), in Trois-Rivières (8.8 MW beginning in 2015) and Matane (7.2 MW beginning in 2015).

SHOC® Technology Demonstration

Proponent:
Innoventé

Funding:
Total project value: $8.5 million
Quebec Ministry of Energy and Natural Resources (Technoclimat Program): $2.5 million
SDTC: $2.7 million

Partners:
IRDA (Institut de recherche et de développement en agroenvironnement)
F. Ménard

Key contact:
Richard Painchaud, President
Innoventé
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E-mail: rpainchaud@innovente.ca

Energy Innovation and Efficiency Success Story

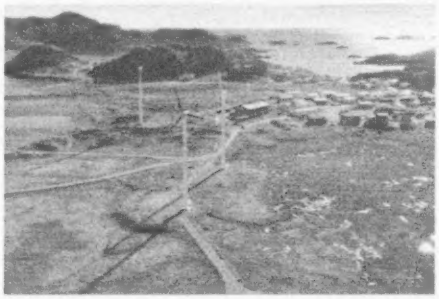
Ramea Wind-Hydrogen-Diesel Pilot Project – Newfoundland and Labrador

Nalcor is currently operating a wind-hydrogen-diesel (WHD) project in Ramea, an island off the south coast of Newfoundland. It is focused on renewable energy storage and grid integration in an isolated diesel-powered community.

The first phase of the project involved the integration of existing diesel generators in Ramea with wind turbines and hydrogen equipment. The wind turbines provide energy directly to the Ramea grid during high-load periods and when the electrical load is low, the wind energy is used to produce hydrogen gas. Hydrogen gas is stored and converted back to electrical energy using a hydrogen-powered generator when wind speeds are too low to operate the wind turbines. The renewable generation provided by the wind turbines and the hydrogen generator is used to offset diesel fuel consumption.

Nalcor's proprietary Energy Management System that automatically dispatches the various generating and storage equipment is undergoing preliminary patent work.

Phase one was jointly funded by the Government of Newfoundland and Labrador, the Atlantic Canada Opportunities Agency (ACOA), Natural Resources Canada and Nalcor. Phase two, which is now under way with funding from ACOA and Nalcor, will continue to test and optimize the system and will replace the hydrogen generator with hydrogen fuel cell technology.



View of Ramea, Newfoundland

Proponent:
Nalcor Energy

Funding:
Direct investment of $11.82 million for Phase I from government agencies/departments and Crown corporations with a further $4.14 million planned for Phase II

Leverage:
Direct investment

Partners:
Partners and collaborators include NL Government, Nalcor Energy, ACOA, NRCan, Memorial University of Newfoundland and Labrador, University of New Brunswick and Frontier Power Systems

Key contact(s):
Cara Pike, Nalcor Energy

Energy Innovation and Efficiency Success Story

Enhanced Oil Recovery in Harsh North Atlantic Offshore Climates – Newfoundland and Labrador

To support research and identify new ways to optimize oil recovery, it was announced on June 10, 2013, that the Research & Development Corporation of Newfoundland and Labrador (RDC) and the Hibernia Management and Development Company Ltd. (HDMC) will invest $1.635 and $1.7-million respectively for the creation of a state-of-the-art enhanced oil recovery research facility at Memorial University's St. John's campus.
Research efforts in the new laboratory will focus on enhanced oil recovery, which is utilized to increase the amount of crude oil that can be extracted from an oil field and thus extend field life. Funding from RDC and HMDC will advance research and development (R&D) capacity at Memorial.

Dr. Wade Locke, a Memorial University economics professor, highlighted in his independent analysis that enhanced oil recovery research has a potential to extend the life of the Hibernia oil field by unlocking 50 to 100 million barrels of oil. If successful, this increase in recoverable oil reserves would translate into between $2.1 billion and $4.4 billion for the provincial government and increase the value of output from the Hibernia oil field by between $5 billion and $10 billion (with prices in the $100/barrel range). Additionally, this project could produce between $25 million and $50 million in R&D investment, given the provincial R&D investment requirements for companies stipulated in the Atlantic Accord.

Glenn Janes, CEO of RDC, states that "building new research labs and facilities is critical to expanding our R&D capacity and strengthening our long-term economic performance and global competitiveness. Applied enhanced oil recovery research represents a strategic investment that is critical to sustaining economic prosperity in Newfoundland and Labrador."

Supporting Enhanced Oil Recovery

Proponent:
Research Development Corporation (RDC)

Funding:
Public direct investment of $1.636 million from Government and Crown Corporations

Leverage:
$1.7 million from the Hibernia Management and Development Company Ltd. (HDMC)

Partners:
Government of Newfoundland and Labrador; The Hibernia Management and Development Company Ltd. (HDMC)

Key Contact:
Patrick Griffin, Director R&D Policy

Energy Innovation and Efficiency Success Story

PowerShift Atlantic – Natural Resources Canada, New Brunswick and Prince Edward Island

PowerShift Atlantic is a multi-year initiative, launched in 2010 as one of Natural Resources Canada's 19 Clean Energy Fund projects currently under way nationwide. It focuses on finding more effective ways to integrate renewable energy sources such as wind energy into our electricity system, with demonstration programs for residential and commercial customers under way across the Maritimes.

PowerShift Atlantic is demonstrating one of the world's first fully grid-integrated virtual power plants designed to allow for more effective integration of wind power. Unlike typical demand response services, the virtual power plant uses load and wind forecasting and aggregation capabilities to perform near real-time load shifting of commercial and residential loads and provide new ancillary services to the grid. The end-uses targeted have storage capacity such has electric hot water heaters and electric thermal storage heating.

The development of software and hardware components is complete and PSA is six months into a one year demonstration phase. The primary objective of this demonstration is to determine if load shifting can provide an economic and effective alternative to building new supply side ancillary services for the integration of wind with minimal or no disruption to participating utility customers.

By remotely shifting cycles a few minutes here and there and combining loads from many customers, PowerShift Atlantic can demonstrate ways to optimize wind-generated energy without requiring change in customer behaviour or consumption.

Approximately 1200 residential and 100 commercial customers are participating. Customers are very receptive to participating in the demonstration project. The amount of energy connected for this demonstration phase will reach over 18 MW, enough energy to power approximately 13 000 electrically heated homes.

Canadian Wind Energy Association – RJ Templin Award for 2012 (PSA representatives Dr. Liuchen Chang, Michel Losier, and Robert Hornung, President CanWEA)

Lead Proponent:

New Brunswick Power

Participating Partners:

University of New Brunswick
Nova Scotia Power
Maritime Electric
Saint John Energy

Funding:

All participating partners
Natural Resources Canada
Government of New Brunswick
Government of Prince Edward Island

Leverage:

Determine if shifting patterns in energy consumption through load shifting can enable utilities to more effectively integrate renewable energy such as wind. In parallel evaluating the customer response to load shifting as a service

Key contact(s):

Deborah Nobes
NB Power
Tel.: 506-458-4838
dnobes@nbpower.com

Energy Innovation and Efficiency Success Story

Solar-Diesel System in Colville Lake, Northwest Territories

The NWT community of Colville Lake is the highest-cost diesel community served by the Northwest Territories Power Corporation (NTPC). It is an "off-grid" community north of the Arctic Circle where fuel to service the community's electricity needs must be trucked in from the south on winter roads.

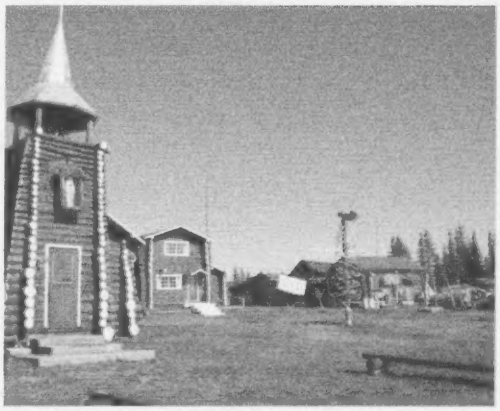
Colville Lake will become the first NWT community to have high-penetration renewables, largely due to a new solar/battery/diesel integrated power plant currently being designed and constructed for the community.

The demonstration project will integrate 54 kW of solar photovoltaic (PV) panels and 200 kilowatt hours (kWh) of batteries with 350 kW of diesel gensets. It is anticipated that during periods in the summer, the solar PV system will be able to supply the entire community's load.

The biggest challenge to high-penetration solar PV power is that the electrical system becomes unstable when a large portion of the electricity comes from non-dispatchable renewables. The battery system will allow the installation of a large amount of PV panels without compromising the system stability.

After the first phase of renewable energy integration, a second phase is being planned that could include a total of 100 kW of solar PV generation and perhaps a 100 kW of wind generation. This could result in a higher capacity factor and a more evenly distributed renewable resource over the entire year.

By installing 400 percent of the community average load in renewables, NTPC hopes to fulfill 20 to 30 percent of the community's energy requirements. The demonstration project is an opportunity for NTPC to build capacity in the operation and maintenance of a hybrid system and also to be able to evaluate the potential to replicate the project in other NWT communities. Similar remote diesel communities across the country and the continent are watching the outcomes of this project.



Colville Lake, Northwest Territories

Lead Proponent:

Northwest Territories Power Corporation (NTPC)

Participating Partners:

Department of Environment and Natural Resources, Government of the NWT

Funding:

NTPC: new diesel plant
$350,000 Government of the NWT
$150,000 NRCan

Leverage:

Funding and expert advice, NRCan

Key contact(s):

Dave Nightingale

Director, Energy – Policy, Planning and Coordination

Northwest Territories Department of Environment and Natural Resources

Tel.: 867-920-3274

E-mail: Dave_Nightingale@gov.nt.ca

Energy Innovation and Efficiency Success Story

NSERC/COSIA/TransAlta Industrial Research Chair in Land Reclamation – National Sciences and Engineering Research Council

Industrial disturbances such as open-pit mining for mineral resources currently affect significant areas in the boreal forest regions of Canada. These activities completely remove vegetation, soil and subsoil to expose the layers that contain the resource. This industrial chair will address questions related to the reclamation of disturbed lands to self-sustaining boreal forest ecosystems common to the region. The research program will focus on the function and underlying processes of forest canopy cover as a prime factor in determining forest successional pathways.

The key activities of the chair will be to develop innovative strategies and techniques for the re-establishment of forests on surface mined lands and to investigate whether these forests develop and display processes and functions comparable to natural ecosystems. Initially the focus will be on the establishment of trembling aspen (an early successional fast-growing tree species native to the boreal forest) and its use as a nurse crop for forest development. In particular, factors such as seedling planting stock quality, site conditions and planting techniques that promote rapid establishment and development of a closed forest canopy will be addressed.

The research will provide the industrial partners with a clear path to reconstruct boreal forests on reclaimed lands. The chair program will help direct future forest reclamation research by leveraging and building on past and current scientific information and will help refine the knowledge and understanding needed for more effective forest reclamation strategies at the provincial, national and international level.

Dr. Simon Landhausser from the University of Alberta

Proponent:

Dr. Simon Landhausser, Professor, Renewable Resources, University of Alberta

Funding:

$1,260,000 NSERC
$1,845,000 cash and in-kind from project partners

Leverage: 1.5:1

Partners:

Albian Sands Energy Inc.
Capital Power Corp.
Suncor Energy Inc.
Syncrude Canada Ltd.

Key contact(s):

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www.rr.ualberta.ca/StaffProfiles/AcademicStaff/Landhausser.aspx

Energy Innovation and Efficiency Success Story

Industrial Research Chair in Unconventional Oil Recovery – National Sciences and Engineering Research Council

The NSERC Industrial Research Chair (IRC) in Unconventional Oil Recovery is a major research initiative undertaken by the University of Alberta in response to developing ecologically viable technologies for extracting or tapping unconventional oil reserves and resources.

The Chairholder, Tayfun Babadagli, is a tenured full-time professor at the University of Alberta. Dr. Babadagli is an internationally recognized scholar in the area of oil recovery and reservoir characterization. Since joining the university in 2002, he has established the Enhanced Oil and Gas Recovery and Reservoir Characterization (EOGRRC) research group. The focus of this research group has been on pore to giga-scale investigations of thermal and solvent applications in light oil/heavy oil/bitumen recovery and the optimization of these techniques considering the reservoir heterogeneity (mainly fracture structures).

The research program will develop efficient in-situ techniques and improve the efficiency of existing techniques for tapping into 85 percent of Canada's unconventional oil reserves, which currently remain untouched because of the limitations of traditional surface mining and extraction.

New techniques and research data will be developed to use minimal amounts of steam and reduce the environmental footprint and cost for companies. This will drastically increase the revenue generated by oil sands production for the country and, more specifically, Alberta. This will also place Canada as a world leader in heavy oil and bitumen recovery techniques.

Dr. Tayfun Babadagli, University of Alberta

Proponent:

Dr. Tayfun Babadagli, Professor, Civil and Environmental Engineering,
University of Alberta

Funding:

$905,000 from NSERC
$1,207,000 cash and in-kind from partners

Leverage: 1.3:1

Partners:

Schlumberger of Canada Ltd.
Canadian Natural Resources Ltd.
Suncor Energy
Petrobank
Sherritt International
APEX Engineering
PEMEX

Key contact(s):

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Web: www.ualberta.ca/~tayfun/

Energy Innovation and Efficiency Deliverable

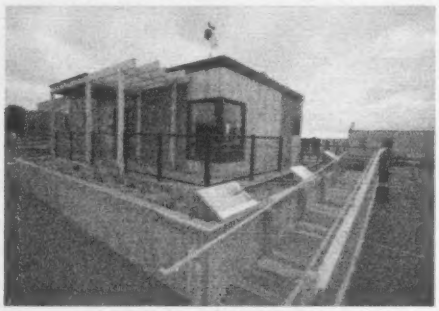
Smart Net-Zero Energy Buildings Strategic Network – National Sciences and Engineering Research Council

The NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBSN) will conduct research aimed at facilitating the widespread adoption of optimized net-zero energy buildings (NZEBs) design and operation concepts in key regions of Canada by 2030. The primary goal of SNEBSN is to investigate the best ways to achieve zero average annual energy consumption at both the building and neighbourhood levels through combinations of passive systems and dynamic building envelope technologies.

Experts from related sectors, including electricity management and urban planning, will work together as part of a network of 15 Canadian universities with headquarters at Concordia University. SNEBSN also involves top researchers working in the general area of energy and buildings and includes the support of 20 industrial and government partners.

The SNEBSN's main outcomes will include:

- development of innovative concepts and systems for cost-effective net-zero energy homes and commercial buildings suitable for Canada and for export through prefabrication
- development of advanced smart building operating strategies that will result in reduced and optimally-shifted peak electricity demand, which will contribute to dramatic reductions in electricity consumption and a reduced need for new central power plants
- development of design procedures and tools for net-zero energy buildings
- training of over 80 highly-qualified personnel who will join industry, universities and government, thereby contributing to achieving the long-term network goal
- provision of input to long-term national policy on the built environment, net-zero energy buildings and communities, and clean energy incentive measures
- significant reduction in emissions through adoption of the technologies, know-how and design techniques developed by the network



Team Ontario's entry ('ECHO') to the 2013 Solar Decathlon

Proponent:

Andreas Athienitis, Professor, Building, Civil and Environmental Engineering, Concordia University

Funding:

$5,000,000 from NSERC
$3,675,000 in cash and in-kind from partners

Partners:

Natural Resources Canada, Hydro-Québec, Kott Group, Thermal Electronics Corp, Pivotry Consulting, Pageau Morel and Associates, Unicel Architecture Corp., Regulvar, SaskEnergy, Gaz Métropolitain Inc., Toronto and Region Conservation Authority, Martin Roy and Associates, Halsall Associates, City of Saskatoon, Saskatchewan Research Council

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